A Summary of Current Program and
Preliminary Report of Progress



# SHEEP AND WOOL RESEARCH

of the
United States Department of Agriculture
and cooperating agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report, a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
January 15, 1963

## OTHER COMMODITY AND FUNCTIONAL REPORTS

A progress report similar to this one is prepared for use by each of the following research and marketing advisory committees:

Citrus and Subtropical Fruit
Cotton and Cottonseed
Dairy
Deciduous Fruit and Tree Nut
Forage, Feed and Seed
Forestry
Grain
Livestock
Oilseeds and Peanut
Potato
Poultry
Rice
Sugar
Tobacco
Vegetable
Economics
Farm Equipment and Structures
Food and Nutrition
Food Distribution
Home Economics
Soils, Water and Fertilizer
Transportation and Storage

Two additional reports of progress are prepared in order to make available the complete research program. They are:

Ornamentals and Other Miscellaneous Commodities
Other Research — Cross Commodity

## ORGANIZATIONAL UNIT REPORTS

All of the material in the commodity and functional reports listed above is the same as that found in the 20 division and 3 service research reports listed below.

Agricultural Research Service (ARS)

Agricultural Engineering
Animal Disease and Parasite
Animal Husbandry
Crops
Entomology
Soil and Water Conservation
Utilization -- Eastern
Utilization -- Northern
Utilization -- Southern
Utilization -- Western
Human Nutrition
Clothing and Housing
Consumer and Food Economics

Agricultural Marketing Service (AMS)

Market Quality
Transportation and Facilities

Economic Research Service (ERS)

Farm Economics
Marketing Economics
Economic and Statistical Analysis
Foreign Development and Trade Analysis
Foreign Regional Analysis

Other Services

Farmer Cooperative Service (FCS)
Forest Service (FS)
Statistical Reporting Service (SRS)

A copy of this report or any of the others listed above may be requested from Max Hinds, Executive Secretary, Sheep and Wool Research and Marketing Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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# INTRODUCTION

Research pertaining to sheep and goats as used in this report is concerned with the production, processing, marketing, and use of meat and fiber produced by these animals. The report covers Farm Research, Utilization Research, Marketing Research, Economic Research, and Consumer-use Research of the USDA and cooperating agencies. Only a brief description of the related work of the State experiment stations and industry is included.

Under each of the Problem Areas there is a statement describing the Program of work underway and the professional man-years devoted to the major kinds of research included. The relative scope of the total research effort pertaining to the sheep and goat industry is indicated by the approximate number of professional man-years employed: 86 by USDA and 75 by the State experiment stations, and about 135 by industry and other organizations.

A brief report of Progress and significant findings for USDA and cooperative programs is given for each phase of the research program. A considerable amount of basic cross commodity and functional research that will supply new knowledge applicable to sheep and wool problems is not included in this report. Such research is included in the functional reports such as "Economics," "Soils, Water and Fertilizer," and in the "Other Research" report.

## Research by USDA

The farm research comprises investigations of breeding, physiology, nutrition, diseases, parasites, housing, and management. This research is conducted by the following divisions of Agricultural Research Service: Animal Husbandry, Animal Disease and Parasites, Agricultural Engineering, and Entomology. In fiscal year 1962 this work involved 37 professional man-years, compared with 70 for State experiment stations and about 60 in industry of which around 40 were working on biological products for use as immunizing agents for preventing diseases and on chemical compounds for use as parasiticides.

Utilization research deals with slaughtering of animals for meat, processing of the meat and of the fibers--wool and mohair. Also, it is concerned with improved equipment and processes. The work on meat is done at the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania, and Beltsville, Maryland. Work on wool and mohair is done at the Western Utilization Research and Development Division, Albany, California, and under contract with State and

foreign-country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area. In fiscal year 1962 the work involved 41 professional man-years. The research in this field of work conducted by States and industry is not reported specifically by commodity.

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by two divisions in the Agricultural Marketing Service: Transportation and Facilities, and Market Quality. In fiscal year 1962 this work involved about 2 professional man-years, compared with about the same effort in the States. The work by industry in this area involves textiles, marketing and processing facilities used for other farm animals and is not available specifically for sheep, wool, or mohair.

Economic research is concerned with marketing costs, margins and efficiency, market potential, supply and demand, outlook and situation, consumer preference and quality discrimination, and improving marketing through research with farmer cooperatives. Fundamental research contributes tools for determining elasticities of demand, statistical formulas, and other analytical guides that can be applied to different situations. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Divisions of the Economic Research Service; Special Surveys Branch, Standards and Research Division, Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service. Approximately 6 professional man-years were devoted to this work in fiscal year 1962, compared with less than 2 in the States; however, most activity in this field of work was reported by function instead of by commodity.

Nutrition and Consumer-use research with meat pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions. Work on textiles and fabrics involves determination of guides for selection and use, and in home care of clothing and household furnishings. This work is done by the divisions of Human Nutrition Research, Consumer and Food Economics Research, and Clothing and Housing Research of the Agricultural Research Service. In fiscal year 1962 this work involved approximately 2 professional man-years, compared with about the same effort at State experiment stations.

## Research by State Experiment Stations

There is included under each problem area a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research.

Consolidating this information for the entire field of interest, we find that in fiscal year 1962 a total of 74.7 professional man-years were spent by the State Agricultural Experiment Stations on sheep and wool research. Sheep and wool research is conducted by the State Agricultural Experiment Stations mostly within the animal science, veterinary medicine, agricultural biochemistry, entomology, agricultural economics, home economics, and agricultural engineering departments. This support is divided among the following areas: increasing efficiency of production, 53.3; diseases and parasites, 16.8; entomology, 0.9; agricultural engineering, 0.2; market quality, 1.3; economic research, 1.3; and human nutrition and consumer-use research, 1.8.

## Research by Industry and Other Organizations

The 135 professional man-years estimated as industry's participation in sheep, goat, wool and mohair research are employed primarily by large commercial ranches in the West and pharmaceutical manufacturing companies. The amount of research effort, especially in utilization and economics of marketing, is difficult to estimate. The animals and their products are merged with other species and products at auction and terminal markets in processing plants, and on through the marketing channels, and research emphasis pertains more to functions than commodities. The size of flocks needed and effort involved for evaluating breeding practices has rested largely with publicly supported institutions, and with the cooperation of owners of private herds. The effects of hormone and hormone-like substances alone or in combination with antibiotics on growth and physiological reaction of sheep is being studied by a few pharmaceutical companies. The potential market for new products developed for use in sheep husbandry is presently limited as compared with opportunities for other types of livestock. Improvements in husbandry and physiology will probably come from publicly supported institutions. If technological advances provided through public research bring about increased sheep production, then industry may take a more active part in research.

With mill consolidation in recent years industrial research on wool has practically disappeared. With the advent of synthetic fibers what was formerly a wool-processing industry lost interest in wool per se and undertook processing of the particular fibers that were in demand. Processors of the synthetics conducted the research needed to adapt the wool machinery to process synthetics and provided the information to

the industry. This development in combination with a serious decline in the financial strength of the wool industry resulted in a shift of scientists from wool research to quality control, mill troubleshooting and short-range developmental work. Industry application of research developed by public institutions is done where it has a potential of profit. There is considerable trade secrecy in the textile industry.

Industry is showing an increasing willingness toward cooperative research with public agencies. This is well illustrated in the chemical field where increasing costs, difficulty, and the time required to secure clearance because of residue problems before a new pesticide can be used on food products make it less attractive for the private companies to work alone. Basic research by private companies is now even less attractive than before and makes increasingly evident the necessity for basic research by public agencies. The advantage of cooperative applied research between public and private agencies is well illustrated in the work with stored products insects. Here literally millions of dollars worth of produce, materials, equipment, storage space and additional manpower are made available by industry at no cost to the Department.

It has been estimated that one billion dollars per year is being expended in building new and modernizing old marketing facilities. Planning of marketing facilities that benefit handlers of commodities flowing through the marketing channels is of such magnitude and affects so many individual and community interests that its nature makes it a public activity. A small Federal staff makes an important contribution to overall market planning which is utilized by architectural and engineering firms to develop plans, drawings and specifications for specific facilities on particular sites.

## Examples of Recent Research Accomplishments

### Sheep breeding.

Sheep breeders are taking advantage of improved strains and breeding systems for producing more efficient farm and range sheep. The value and use of Targhee sheep, long established in the Western and Southwestern range areas of the United States, has been tested in Hawaii and this USDA developed breed was found superior to the other sheep commercially available in the area. The improvement was primarily in the production of heavier lambs at weaning time. Use of improved rams on the typical ewes of the Navajo Indian Reservation, in only two generations, nearly doubled the production of grease wool; increased clean fleece weights as much as a third; and increased staple length as much as forty percent. After three or four generations, weaning weights of lambs had increased by 10 to 25%.

The Columbia - Southdale strain, being developed as a dual purpose sheep under Eastern United States farm conditions, is already performing favorably as compared to other breeds used in the trials. Crossbreeding research has established that lamb production per ewe can be increased as much as 30% in a three-breed rotation system. About 90% of lambs marketed for meat in the United States are crossbred.

Federal Lamb Grades Found Desirable.

The Department of Agriculture, in cooperation with representatives of the sheep and lamb industry, developed a revised set of Federal grades for lamb and made them effective in March 1960. In response to a request from the House of Representatives Committee on Agriculture, a study of the effects of this change, and the role of Federal grades for lamb in general was initiated by the Division. No support was found for the view expressed by certain industry groups in 1959 that Federal lamb grades were hurting rather than helping producers. The 1958-61 lamb price decline was principally caused by the high production of lamb and substitute meats. There is no evidence that Federal grades were a factor. On the contrary, their impact on lamb marketing is important and positive. They promote competition by helping the small firms compete with the large. They lower marketing costs. They help encourage production of desirable types of lambs. They help consumers consistently find the kind of lamb they prefer.

New Process for Making Wool Shrink- and Muss-resistant to be Commercialized.

Last year the Agricultural Research Service reported it had developed an entirely new method for making wool fabrics shrink- and muss-resistant, and that the method was being evaluated by a number of industrial firms. One of the large wool fabric manufacturers who treated several thousand yards of fabric by this method and evaluated it in a market survey, is purchasing more suitable processing equipment and will begin large-scale commercial production in early 1963. Because the treatment does not harshen or weaken the fibers or change the original texture of the fabric, as do some of the treatments now in use, potential applications cover a broad range of different kinds of woolen and worsted articles, and the number of manufacturers evaluating the treatment continues to grow. The name WURLANIZE has been chosen for this new process, WUR coming from Western Utilization Research and Development Division and LAN from lana, the Latin word for wool.

Reducing Livestock Loss and Damage.

FCS is studying loss and damage to livestock through handling and transportation during marketing. Farmers and their livestock marketing agencies incur a loss of more than $50 million each year due to injury, death and other forms of damage associated with the movement of live animals from farms and feedlots to final destinations. One study showed that losses on transporting and handling sheep and lambs amount to $2 million a year; abusive handling was a principal factor.

## Programs of Marketing Service and Education

The Research and Marketing Act of 1946 authorized a number of activities in addition to research. Some of these are: "to conduct and cooperate in consumer education...to collect, tabulate, and disseminate statistics on marketing agricultural products...to develop and promulgate - procurement standards and specifications for agricultural products...to inspect, certify, and identify the class, quality, quantity and condition of agricultural products...and to conduct information programs designed to eliminate artificial barriers to free movement of agricultural products."

Part of two service programs are included in this report: one provides statistics on sheep or wool; the other provides standards, grades, and market news. Both were selected because they are closely related to research work included in the report.

The value of service, educational, and regulatory programs can be observed every day around us. The statistics are used constantly in making business decisions by persons in all segments of the sheep and wool industry from producers to consumers. Inspection, grading and regulatory activities insure a steady supply of wholesome meat and meat products. A classic example of research-education-regulatory cooperation is the eradication of the screwworm in the Southeastern United States. These examples illustrate how cooperative activity can assist in helping all of us to enjoy the high standard of living which American agriculture makes possible.

# SHEEP AND GOATS - BREEDING
Animal Husbandry Research Division, ARS

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding and selection need to be tested. Breeding studies on reproductive efficiency, as well as on the inheritance of feed efficiency, rate of gain and carcass quality deserve emphasis. Basic research on the inheritance of blood antigens is needed to implement other sheep genetic studies.

## USDA PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons and studies of gains resulting from crossing of breeds. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Inheritance of blood antigens is being investigated in cooperation with the California Experiment Station. Cooperation is maintained with 15 other State experiment stations. Several of the studies contribute to the Western, Southern and North Central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 1.5 are devoted to genetics and interrelation of performance traits, 3.1 to selection and systems of breeding, and 1.7 to program leadership.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 18.3 professional man-years, including 4.1 in genetics and interrelations of performance and 14.2 in selection and systems of breeding. Sheep breeding studies are coordinated through the W-61, S-29, and NC-50 regional projects. Eleven State stations and USDA are cooperating through the W-61 regional project in the development of selection criteria for the

genetic improvement of carcass merit of sheep. Initial efforts are concentrated on defining carcass merit through measures of the amount of lean in relation to fat and bone and in studies of eating quality. Seven States and USDA are cooperating through regional project NC-50 to determine heritabilities and interrelations of productive traits to facilitate improvement of lamb production through breeding. In the Southern region 10 States and USDA are cooperating through regional project S-29 to investigate genetic and physiological factors affecting reproduction of sheep. These regional and other State projects are producing information on genetic parameters of sheep, evaluation of breeds and strains, improvement of selection methods and performance testing and crossbreeding to increase efficiency of production and to develop improved strains of sheep.

Industry and other organizations conduct very little research in sheep breeding. An example of direct participation in research is the cooperative effort of the Redd Ranches with the Utah and Colorado State stations and USDA in applied research on improvement of range sheep through breeding. Similar improvement efforts are being carried out with other privately owned flocks. Breed associations and other organizations are cooperating in a number of performance testing and selection programs. The actual research effort provided by industry and other sources in sheep breeding is probably not more than 2.0 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Genetics and Interrelations of Performance Traits

#### 1. Effects of Genetic and Environmental Factors.

At Dubois, Idaho, genetic and environmental effects on eight weanling traits of 3,227 Rambouillet, Targhee, and Columbia lambs reared during the topcross testing period 1955 through 1961 at Bozeman, Montana, have been estimated. Age of dam, type of birth and rearing, and age at weaning each had significant effects for nearly all seven years on weaning weight, body type, condition (fatness) and staple length at weaning in all breeds. Sex differences (differences between ewe and wether lambs) were significant, in general, only for weaning weight, face cover, and staple length. The sex differences seem to be more important in the Rambouillets than in either of the other two breeds. The type of winter feeding of the dam had no significant effect upon the weanling traits of the offspring. Face cover seemed to be affected significantly only by sex differences. Effects on side grade and crimp of wool at weaning were almost nonexistent, and neck folds were affected only to a small extent by sex and type of birth and rearing. Effects on staple length seemed to be somewhat more pronounced in the Rambouillets than in either the Targhees or

Columbias, although this may be simply a function of greater accuracy of measurement of staple length in the Rambouillets.

A study of the genetic and environmental effects on 26 fleece and body traits and the phenotypic correlations among these traits for 3,550 yearling ewes of Columbia, Rambouillet, and Targhee breeds for the years 1955 through 1958 has been completed. For the traits used in the yearling indexes, namely, body weight, staple length, body type, condition, fleece weights, face cover, neck folds and fiber diameter, differences caused by years were the largest. Other effects which were important for nearly all these traits were inbreeding, type of birth and rearing, and to a lesser extent, age from birth to shearing. Age of dam effects were important for body weight, staple length, fleece weight and for body type. Inbreeding of the dam and band in which herded were not especially important. The genetic differences among sheep (independent of inbreeding effects) caused by the several mating systems in use were sufficiently large to be highly significant for all traits in the Rambouillet breed, were of less importance in the Targhees, and relatively unimportant in the Columbia breed.

It was observed that the absolute magnitudes of the effects at yearling age caused by differences in maternal environment and days of age were (for those traits most affected by environment--body weight, type, and condition) generally only 30 to 60% of those at weaning age. However, the effects of the animal's own inbreeding at yearling age commonly ranged from 110 to 180% of those at weaning age illustrating the proportionately greater reliance of the animal upon itself as it matures. (AH b1-6, b1-14)

2. Correlations Among Traits.

All possible phenotypic correlations, independent of measurable environmental and genetic effects were calculated for 26 fleece and body traits of yearling ewes. The degrees of freedom were such that all correlations above .06 to .08 were significant. The correlations among fleece traits tended to be higher (.10 to .20 higher) for the coarser and more variable Columbia and Targhee breeds than for the Rambouillet. The only notable correlations between fleece and body traits were those involving body weight and circumference of chest and grease and clean fleece weight. All others were low, most being nonsignificant. The correlations among body traits generally were moderately high (.40 to .70) for those traits which describe torso dimensions, such as body type, body width, or body depth. Circumference of chest and body type were the traits most highly correlated with body weight, .67 and .57, respectively. However, body weight generally had the highest correlation with all body traits. Except for circumference of chest, the measured traits appeared to be no more accurate in describing other body traits than scored traits yet are more time consuming to measure or observe. Circumference of the chest seems to be

the most useful of all measured traits and is one of the most easily measured.

In additional work on methods of estimating clean fleece weight, it was found that multiple regression equations involving grease fleece weight, staple length, body weight, fiber fineness, machine reading and crimps per inch produced multiple correlations with clean fleece weight ranging from .88 to .96. These were slightly higher than those obtained when using small side samples to predict clean fleece weight. It was also found that when grease fleece weight, machine reading, and staple length were used in the regression equations, the other traits contributed but very little to the accuracy of the prediction equation. The side sample method appears somewhat more accurate if only a single trait is to be used; however, its limited superiority seems insufficient to justify the disadvantages in time and expense requisite to its use. To further substantiate these findings the multiple regression equations subsequently were used to estimate whole clean fleece weights on data entirely independent of those from which the equations were derived. The data consisted of observations on 198 yearling and mature ewes and rams. Correlations between the estimated and actual clean weights ranged from .82 to .93 for fine, 1/2, 3/8, and 1/4 blood fleeces. Correlations between estimates obtained by scouring small side samples and the actual clean weights on the same fleeces ranged from .68 to .91. Comparable correlations involving grease weight and actual clean weight ranged from .70 to .89 and those involving squeeze machine reading and clean weight ranged from -.79 to -.91. These results corroborate earlier conclusions that estimating clean fleece weights from appropriate multiple regression equations is generally the most satisfactory means of obtaining these estimates. (AH b1-6)

3. Blood Serum Analysis.

Blood serum protein fractions were determined on 80 Targhee, Columbia, and Rambouillet ewes bled during 1960. The objective was to investigate the relationship between serum proteins and degree of inbreeding by lines. There appeared to be no important relationship between the average inbreeding and the average levels of serum protein fractions of the line. These data tend to confirm earlier findings, however, of consistent breed differences for serum protein fractions, Rambouillets having lower gamma globulin and higher albumen levels and higher albumen-globulin ratios than the Columbias, with the Targhees occupying an intermediate position. (AH b1-6)

4. Genetics of Feed Utilization.

Analyses on the 5 years of data obtained on the efficiency of gain of 226 individually fed Rambouillet ram and ewe lambs and a comparable lot of 218 group fed lambs have provided additional estimates of the effects of age of dam, type of birth and rearing, sex,

band and age of lambs on a large number of performance traits studied including efficiency of feed conversion and rate of gain on feed test. Heritability estimates of these traits in many instances varied between the two conditions under which the sheep were managed for the feed test, however, evidence of large sampling error due to limited numbers discounts the conclusion of different heritabilities under different conditions. Heritability estimates for certain traits were similar for the two conditions. (AH b1-13)

5. Investigation of Blood Group Relationships in Sheep.

Cooperative work with the University of California at Davis, concerned with blood groups in sheep and closely related species, has been continued. A rather unusual trizygotic set of Suffolk triplet lambs has been found. The female member of this set possessed red blood cells of two distinctly different serological types, one of which she shared in common with the two males and the other which was unique to herself. The ratio of the two kinds of red cells were originally 50:50, but by 10 months after this test the ratio was 95:5. This regression of one of two populations of chimeric blood cells has been reported in man but not in chimeric or mosaic twins and triplets in sheep. Although this ewe lamb would pass as a normal, potentially fertile female, the results of the blood-typing and skin-grafting experiments indicate that she was joined in a communal vascular system with the two ram lambs during prenatal life and therefore is probably a freemartin. In another case a so-called "hermaphrodite" female lamb born twin to a male was also found, by the use of blood typing techniques, to actually be a freemartin (a rare event in sheep).

Serum samples from 100 sheep were examined for their content of hemolysins for cattle red cells. Six of the samples contained antibodies for blood factor $F_1$ of cattle. Successful transformation of J-negative goat red cells to J-positive was accomplished by placing them in plasma from J-positive goats, much in the manner described for cattle red cell transformation.

Isoimmunizations were performed using 35 rams and 2 ewes as recipients. These immunizations were planned to stimulate antibodies for known blood factors in order to help replenish stock antisera and reagents. Antibodies for 5 blood factors were duplicated and in addition antibodies for a previously unrecognized factor were found. Six rabbits were used to replenish the supply of anti-Z reagent. A new antibody was encountered which acts as an agglutinin rather than a hemolysin.

Blood typing of approximately 900 ewes and their mates in 1961 from inbred Rambouillet lines and the selected control group of the Rambouillet, Targhee, and Columbia breeds at Dubois, Idaho, has been done at Davis, California. Blood samples will be collected on the

1962 weanling offspring. Studies will be made regarding calculated levels of heterozygosity of the blood group factors and of the association between blood groups and certain production traits. (AH bl-15)

B. Selection and Systems of Breeding

1. Breed Comparisons and Crossbreeding.

This work was undertaken to compare breeds in their ability to produce wool and lambs and their value in a crossbreeding program designed to study increased production due to hybridization. Initial comparisons involved the Hampshire, Shropshire and Southdown breeds. The total production of these sheep has been measured by an index which combines the pounds of lamb weaned with the pounds of wool produced divided by the fall body weight of the ewe. The average production index for the past 14 years is 70.0, 57.9, and 53.6 for the Hampshires, Shropshire, and Southdown breeds, respectively. (AH bl-1)

In the crossbreeding studies, the two-breed crosses include Shropshire, Southdown, and Merino rams mated to Hampshire ewes; and Hampshire, Southdown, and Merino rams mated to Shropshire ewes. The average production index of all two-breed crosses was 71.4. The comparable average of the purebred parents making up these crosses was 63.1. The average index for the crosses involving the Hampshire ewes was 92.3 compared to 54.7 for the Shropshire ewes. In 1961, the three-breed crosses involved the mating of Hampshire, Shropshire, Southdown, and Merino rams to two-breed cross ewes; and two-breed cross rams to purebred Hampshire, Shropshire, and Merino ewes. The average index for the crossbred ewes mated to purebred rams was 88.3 and for the purebred ewes mated to crossbred rams was 88.7. Thus, the three-breed crosses show increases of 39% over the comparable average index of 63.7 for pure breeds involved.

The total pounds of lamb weaned from a flock of sheep depends upon the weight of the individual lambs and the number of lambs weaned. The number of lambs weaned is dependent upon the fertility and prolificacy of the ewes and the livability of the lambs. To study the effect of crossbreeding on fertility, prolificacy and lamb livability of purebred vs. 2-, 3-, and 4-breed cross matings, data were analyzed which included a total of 2962 ewes bred, 2646 ewes lambing and 3428 lambs born alive for the years 1952-1959. Fertility was measured by the percent of ewes lambing of ewes bred. It was found that 88% of the purebred ewes lambed of ewes bred, 89% of the ewes lambed which produced 2-breed cross lambs, 90% of the ewes lambed which produced 3-breed cross lambs and 92% of the ewes lambed which produced 4-breed cross lambs. Prolificacy was measured by the percent of lambs born of ewes lambing. The percentages for ewe producing purebred lambs, 2-breed cross lambs, 3-breed cross lambs, and 4-breed cross lambs, were 134, 128, 148, and 149, respectively.

Lamb livability was measured by the percent of lambs born alive to total lambs born and lambs weaned of live lambs born. The percent of lambs born alive of total lambs born for purebred mating, ewes producing 2-, 3-, and 4-breed crosses was 93, 95, 95, and 97, respectively. For lambs weaned of live lambs born these percentages were 82, 84, 84, and 89. Since the percent of lambs weaned of ewes bred included fertility, prolificacy and lamb livability it is the best single measure of lamb productivity. The percentages for purebred, 2-cross, 3- and 4-breed crosses for this trait were 90, 92, 104, and 117, respectively.

Significant differences were found between years, age of dam, type of birth and breeds and crosses for fertility, prolificacy, and lamb livability except between years for livability at birth. Age of dam showed an important effect on prolificacy with an increase from 126 to 153 lambs born of 100 ewes lambing from 2-year-old ewes to those 9 years and older. Fertility and lamb livability tended to be lower for the young and old ewes than for those of the middle ages. The peak for percent lambs weaned of ewes bred was reached at 4 years of age. A higher percent of single lambs was born alive and a higher percent of single lambs born alive was weaned than of twins.

In purebred matings Hampshires, Merinos and Columbia-Southdale, excelled over Shropshires and Southdowns in percent of lambs weaned of ewes bred. Hampshires and Columbia-Southdales ranked highest in prolificacy, and Merinos ranked highest in fertility and lamb livability among the breeds studied.

Fertility, prolificacy, lamb livability and overall reproductive ability were generally higher for crossbred than for purebred matings. Furthermore, there was an upward trend with an increase in the number of breeds involved in the cross. Two-breed crosses tended to rank in somewhat the same order as the dam's breed and were not significantly greater than the purebred matings for any of the traits studied. Consistent effects of breeds or breed combinations were not readily apparent in reproductive traits of 3- and 4-breed crosses. Average increases in percent lambs weaned of ewes bred were 2.1, 14.9, and 27.1 for 2-, 3-, and 4-breed crosses, respectively, over the comparable averages of the purebred parents. (AH b1-2)

Merino ewes were mated to Hampshire, Shropshire and Southdown rams, and their production compared to Merino X Merino matings to study the probable increase in total production resulting from mating wool-type ewes to meat-type rams. In 1961, the average index for purebred Merino matings was 61.8, while Merino ewes mated to Hampshire, Shropshire, and Southdown rams gave average production indexes of 118.3, 115.8, and 83.8 for each cross, respectively. When Hampshire-Merino, Shropshire-Merino, and Southdown-Merino crossbred ewes were mated to meat breed rams an average index of 102.1 was obtained. (AH b1-4)

2. New Strains of Sheep for Lamb and Wool Production.

Work toward the development of the Columbia-Southdale strain of sheep is being continued at Beltsville, Maryland, and in cooperation with the Vermont Agricultural Experiment Station at Middlebury, Vermont. These sheep are being developed as a dual-purpose breed to produce a maximum of high quality 3/8 and 1/4 Blood wool and a desirable meat-type lamb under Eastern farm conditions. Data from Beltsville and Middlebury concerned with weanling and yearling traits of this strain were combined in an analysis which resulted in estimates of heritabilities, genetic and phenotypic correlations and a comparison of the Columbia vs. the Columbia-Southdale strain. Significant effects of year of birth, age of dam, type of birth and rearing, sex, breed and station were found. The traits most influenced by the measurable environmental factors were weaning weight, type and condition, and yearling body weight and fleece weight. The year of birth was the most consistent cause of environmental differences of any of the effects studied. Heritabilities of weaning weight, type and condition, and yearling body weight were found to be 0.14, 0.14, 0.15, and 0.13, respectively. Heritabilities for yearling type, condition, fleece weights, fleece characters and staple length were 0.32, 0.45, 0.67, 0.66, and 0.73, respectively. Of the 36 phenotypic correlations all were positive with the exception of four and only one of these, between yearling fleece weight and fleece character, was statistically significant. Negative genetic correlations were found between yearling body weight and weanling type; yearling fleece character and staple length; yearling fleece weight and yearling condition, type and fleece character. Staple length was negatively correlated with yearling condition and fleece character. However, the majority of all traits were positively correlated and weaning weight showed a positive relationship with every other trait. In the comparison between the Columbia and the Columbia X Southdale it was found that the Columbia sheep were heavier in weaning weight, yearling weight, had heavier fleeces and greater yearling staple length. The Columbia X Southdale sheep ranked higher in weaning type, condition, yearling type, condition and fleece character scores than the Columbia. (AH b1-3)

Seasonal restrictions of reproduction in sheep results in uneven supplies of slaughter lambs throughout the year. In many areas it is advantageous to produce lambs in the fall of the year, a time when present domestic breeds do not reproduce in abundance. More intensive and more efficient lamb production, especially in farm flocks, would be greatly facilitated by strains of sheep which would efficiently reproduce every 6 to 8 months and do this without seasonal restrictions. The development of such a strain of sheep will demonstrate the effectiveness of selection to change reproductive frequency and to remove seasonal restrictions on reproduction. Thus, work has been started on the development of a strain of sheep capable of reproducing more than

once per year. Matings are made in April, December, and August to produce three lamb crops in two years. Lambs are weaned at 60 days of age. Of 122 ewes bred in April-May of 1961, 61 lambed producing 71 lambs. A total of 21 of these lambs were born dead and 35 were weaned. Ewes lambing in September were rebred in December. Of 90 ewes bred, 40 lambed, producing a total of 50 lambs of which 42 were weaned. (AH b1-17)

3. Comparisons Among Systems of Breeding.

The investigation of systems of breeding for improvement of range sheep has continued at Dubois, Idaho, with comparisons being made among systems involving inbred line formation, line crossing, top-crossing inbred sires on unrelated ewes, mass selection without inbreeding (selected control), random mating without inbreeding (stabilized control), and recurrent selection of sires for superior general combining ability. The comparisons are based on the merit of unselected weanling offspring produced by each system for the Rambouillet, Targhee, and Columbia breeds over the four years 1958-61.

In general, the systems involving top-crossing of inbred sires and mass selection without inbreeding (selected control) continue to produce offspring of superior overall merit. Within the Rambouillets, the top-cross offspring remain superior in weaning weight; but the selected control offspring are superior in overall merit, chiefly because of more open faces, less wrinkled necks, and longer staple lengths. The two systems are very nearly equal in the Targhees, while the top-crosses have a slight superiority in overall merit in the Columbias. Weaning weights for the two systems are almost identical in the Columbias.

The line cross offspring continue, in general, to occupy an intermediate position (along with the recurrent selection test offspring) although their position in the Targhees, where they have ranked first in overall merit and weaning weight for the past two years (1960 and 1961), is relatively more favorable than in either of the other two breeds.

Offspring from the stabilized control and the inbred lines are inferior to those from all other systems. The stabilized control offspring generally are superior in weaning weight but slightly inferior in overall merit (chiefly because of slightly more covered faces and wrinkled necks in the Rambouillets and Targhees and shorter staple length in the Columbias) to the inbred line offspring. Only two years of data are available on Targhee and Columbia stabilized control offspring, which makes their positions relatively more tentative than that of the Rambouillet stabilized control. (AH b1-5)

4. Testing of Inbred Lines.

The testing of inbred lines by top-crossing inbred sires upon noninbred test ewes has continued at Dubois, Idaho, and Bozeman, Montana. At Dubois, 57 sires representing all 27 inbred lines of Rambouillets, 20 inbred lines of Targhees, and 10 inbred lines of Columbias were tested on three to seven noninbred test ewes per sire. Final results also are available on 82 Rambouillet sires from 19 Rambouillet inbred lines, 40 Targhee sires from 8 Targhee lines, and 42 Columbia sires from 9 Columbia lines tested at Montana during the period 1955 through 1961. In addition, results are available on 14 Rambouillet, 7 Targhee, and 7 Columbia purchased sires along with an equal number of noninbred (selected control) sires tested during the same period. Results are based on the average merit of unselected weanling offspring.

Three-year averages (1959-61) of test results at Dubois reveal that 9 of the 27 Rambouillet inbred lines had top-cross offspring superior to those of the best selected control pen in overall merit (index), and 20 of the inbred lines were superior to the best selected control pen in weaning weight. Twenty of the inbred lines had top-cross offspring exceeding those of the purchased rams in both overall merit and weaning weight. Six of the 20 Targhee lines tested had 3-year averages for overall merit superior to that of the best selected control pen, and 7 had averages for weaning weight superior to that of the best selected control pen. Thirteen of the 20 lines had averages for overall merit and 7 had averages for weaning weight better than those of the purchased rams. Eight of the 10 Columbia inbred lines had 3-year averages for overall merit and 5 had averages for weaning weight superior to those of the best selected control pen. However, only 2 of the lines had test progeny averages (for both overall merit and weaning weight) superior to those of the purchased Columbias.

Because the lines tested at Montana could not all be tested simultaneously in any year, it was difficult to make accurate individual comparisons among all the lines. However, comparisons of the 7-year averages over all inbred lines, all purchased rams, and all noninbred (selected control) rams within each breed reveal that for overall merit in both the Rambouillets and Targhees the selected control progeny ranked first, the inbred line progeny second, and the purchased sire progeny last. In the Columbias, however, the purchased sires had superior progeny, the line sires ranked second, and the selected control sires were poorest. These rankings for overall merit were identical to those for comparable three-year averages of tests at Dubois for all breeds although they are based on averages which include only 9 of the 27 Dubois Rambouillet inbred lines, 5 of the 20 Targhee lines, and 6 of the 10 Columbia lines. For weaning weight, the respective rankings in the Columbias were identical to those for overall merit, both at Montana and Dubois. In the Rambouillets,

however, the selected control progeny were first at Montana and last at Dubois; the purchased sire progeny ranked second at both locations; and the progeny of inbred sires ranked last at Montana and first at Dubois. For the Targhees, the progeny of selected control sires were first in weaning weight at Montana and last at Dubois, the purchased sire progeny had exactly the opposite ranking at each location, and the progeny of inbred sires were second at each location. The above differences in Rambouillet and Targhee test results at the two locations probably can be attributed partly to sampling variation associated with differences in the kind and number of test animals used and partly to the fact that only a small porportion of the lines tested at Dubois were also tested at Montana. This testing will be continued until more decisive results can be obtained, particularly for individual line comparisons. (AH b1-14)

5. Selection for Range Sheep Improvement.

Increased lamb and wool production through use of high quality rams has been clearly demonstrated over four generations of selective breeding at Fort Wingate, New Mexico. The project was initiated in 1952 with ewes obtained from the Navajo Reservation with average clean fleece weights of 2.0 pounds and staple lengths of 2.1 inches. Three random groups of these ewes were bred each year to highly selected rams of the Targhee and Rambouillet breeds and of the weaving wool strain from Fort Wingate, respectively. The fourth group was bred to rams of the same breeding as the original ewes and selected at random each year. Second generation ewes sired by the weaving wool rams produced clean fleece weights about 50% heavier than the control or representative Reservation ewes. Marked increases over the controls of 36 and 23%, respectively, were found for the Targhee and Rambouillet sires. Similar differences were found for staple length with increases of 71, 29, and 33%, respectively, for the 3 breeds of sires. Average weaning weights of lambs at 120 days were also much higher for the improved sires with an increasing advantage through the first four generations. Targhee sires showed the greatest advantage of 26% followed by 25% for weaving wool sires, and 15% for Rambouillet sires over the average reservation lambs born under the same conditions in the same year.

Weaning weights as affected by pasture differences were studied at Fort Wingate during the years 1958 to 1961. During 1960-61 the ewes with their lambs were herded on a new range about 6 miles west of the range used in 1958-59. The new range had better watering facilities in terms of number and distribution or location of the tanks. There were fewer trees on the new range and also a greater variety of range plants. Precipitation during each of the four years was 10.78, 11.72, 8.03, and 10.14 inches, respectively, for 1958, 59, 60, and 61. Average weaning weights of lambs on the new pasture were 12.4 pounds greater for the ram lambs and 11.1 pounds greater for the ewe lambs than for the old pastures. These figures include lambs from all eight

breeding groups maintained at the Fort Wingate station. Rather large differences in weaning weights of lambs between breeding groups were noted between the 1958-59 season and the 1960-61 season. On the poor range, advantage in weaning weights of the two improved strains and the Targhee line over the old type Navajo ram lambs was about 2 pounds. But during the relatively good year of 1960-61 on the better range this advantage in weight of the improved strains over the old type Navajo lambs was about 10 pounds in the weaving wool and Targhee lambs and 8 pounds for the fine wool strain. For the ewe lambs these differences were 3 pounds advantage on the poor range and 10 pounds advantage on the good range. This same trend was also noted between the improved strains in the demonstrational groups where Targhee rams, weaving wool rams and Rambouillet rams are being used to demonstrate the grading up of the average reservation sheep through breeding and selection. These weight differences, no doubt, illustrate that the advantages of improved strains are greater under good feed conditions. (AH b1-10, b1-11, b1-12)

Research on the rate of improvement in wool and lamb production resulting from a practical breeding and selection program under range conditions is being investigated at the Redd Ranches, La Sal, Utah, in cooperation with the Utah and Colorado State Experiment Stations. In 1961, 201 ram lambs were saved of 501 ram lambs weaned. The selected lambs averaged 92 pounds in body weight, their fleeces averaged 1.80 inches in staple length, and face cover was scored at 3.01, showing advantages over all lambs weaned of 11 pounds, 0.14 inches and 0.2 score, respectively. Of the ram lambs that were saved, 74.6% were polled, 18.4% were horned, and 7.0% had scurs as compared with 67.9, 24.4, and 7.7, respectively, for all lambs weaned. (AH b1-16)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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## SHEEP AND GOATS - PHYSIOLOGY
Animal Husbandry Research Division, ARS

Problem. Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also, more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

### USDA PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and El Reno, Oklahoma, and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with five State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 3.7 professional man-years. Of this number 1.7 are devoted to physiology of reproduction, 0.1 to environmental physiology, 1.5 to physiology of wool and fiber, and 0.4 to program leadership.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 8.0 professional may-years including 3.9 in physiology of reproduction, 2.3 in

environmental physiology, and 1.8 in the physiology of growth and development. This research is currently being conducted by stations in all four of the regions with research in two regions being coordinated through S-29 and W-46 regional projects. In the Southern regions, 10 States and USDA are cooperating through regional project S-29 to investigate physiological, as well as genetic, factors affecting reproduction in sheep. In the Western region 10 stations and USDA are cooperating through regional project W-46 to study effects of environmental stresses on physiological responses of range cattle and sheep.

Research at the State experiment stations in sheep physiology is concerned primarily with the endocrinology of seasonal breeding behavior and other aspects of reproduction and means of altering them. Environmental physiological studies are mainly concerned with stresses of nutrition and temperature. In work on growth and development the effects of hormones, hormone-like substances and the feeding of specific metabolites such as sodium proprionate are being studied.

Industry and other organizations conduct very little research in sheep and goat physiology. The effects of hormones and hormone-like substances alone or in combination with antibiotics on growth and physiological reaction of sheep are being studied by a few pharmaceutical manufacturing companies. Artificial breeding associations are conducting a little experimental work with artificial insemination of sheep and goats. It is estimated that research by industry and other organizations amounts to not more than 3.0 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Physiology of Reproduction

#### 1. Flushing Studies with Range Sheep.

##### a. Effects of Feed and Length of Flushing Period on Lamb Production in Targhee and Columbia Range Ewes.

Oat supplementation (.7 lbs per head per day) in the years 1957 to 1959 had a significant effect in mature ewes on number of live lambs born, pounds of live lamb born, and pounds of lamb weaned at Dubois, Idaho. On the basis of ewes present at lambing time the best treatment increased number of live lambs born per ewe 0.24, the weight of live lambs born 2.5 pounds and weight of lambs weaned 18.6 pounds. A short flushing period (17 days) immediately prior to breeding increased lamb production over the controls. Extending this period an additional 17 days during breeding produced no further increase in production but increased costs. A further 17-day extension caused an apparent production decline from that obtained by shorter flushing periods.

Ewes on native grass hay fed in drylot for 17 days prior to breeding had lower lamb production than those maintained on dry, native pasture. Alfalfa pellets had an apparent but nonsignificant flushing effect on lamb production in mature ewes. Neither oats nor alfalfa pellets had significant flushing effects on two-year-old ewes.

Both oat and alfalfa pellet supplementation significantly increased body weight during treatment in mature and two-year-old ewes. Change in body weight during treatment was not significantly correlated with lamb production. (AH b1-7)

b. The Effect of Length of Supplemental Feeding Prior to Breeding on Lamb Production in Rambouillet Range Ewes.

Approximately 630 mature Rambouillet ewes were given no supplement (control) or were supplemented with 1 pound of a 50% barley, 50% alfalfa pellet per head per day for 14 or 21 days prior to breeding and for the first 16 days of breeding at Dubois, Idaho.

There were no significant differences among treatments in lamb production. These negative results with Rambouillets in contrast to the positive results from partially contemporaneous studies with Columbia and Targhee ewes at this station (1957-1959) suggest that the Rambouillets, believed to be better adapted to dry range conditions than Columbia and Targhees, may have been under more nearly optimum feed conditions for highest lamb production than the other breeds. Consequently supplementation did not increase Rambouillet lamb production. The different composition of the supplements given the ewes in the two experiments exclusive of TDN differences is another possible explanation for the different results.

The differences in lamb production among years were highly significant. Part of these differences was due to the depressing effect of vibriosis on lamb production in 1961. (AH b1-7)

c. Effects of Management and Length of Flushing Period Prior to Breeding on Lamb Production in Columbia Range Ewes.

Columbia ewes at Dubois, Idaho, were supplemented with 0.5 or 1.0 pounds of oats per head per day for 17 or 34 days prior to breeding. Oat straw was used to lower the condition of two of the treatment groups prior to administration of the oat supplement. Preliminary results indicate a year x treatment interaction on lamb production. None of the flushing treatments applied in the fall of 1960 resulted in a greater response than the unsupplemented control. However, in the fall of 1961, following fall rains which produced a good regrowth of grass prior to breeding time, the six flushing treatments increased lambing rates by an average of 6.5% more lambs born than the

untreated control. The best treatment (oat straw 34 to 18 days before breeding and 0.5 pound oats for 17 days prior to breeding) increased percent of lambs born by 16.9% above the controls.

This study will be continued another year in an effort to get more conclusive results. (AH b1-7)

2. Mating Behavior.

Variation in air temperature, wind velocity, cloud cover, precipitation, brightness of moonlight, type of artificial light at night (sealed beam spotlight or infrared illumination), age, inbreeding, body weight, semen score and previous use had no important influence on mating behavior as observed at Dubois, Idaho.

In one-sire pens Rambouillet rams appeared to be more active than the Targhees and Targhee rams were more active than the Columbias. Number of ewes in heat and individual ram differences independent of number of ewes in heat were the most important factors affecting mating behavior in the ram. The averages for various traits observed during breeding when one, two, or three ewes, respectively, were in heat are: teases/hour 0.95, 1.45, 2.31; mounts/hour 1.35, 2.14, 3.58; matings/hour 0.34, 0.55, 0.98; minutes lying down/hour 22.46, 17.59, 15.59; minutes eating/hour 9.46, 8.57, 8.50; and mounts per mating 4.75, 4.31, 4.63. Number of matings was moderately to highly correlated with the other mating behavior traits. Mating behavior traits were not significantly correlated with fertility. Stimuli such as initial introduction into breeding, number of ewes in heat and feeding had greater influence on mating behavior than the hour of the day or amount of light.

Mating behavior of the ram in the multi-sire pen was also studied. When a particular combination of rams was placed in a pen the dominance of one ram over another was quickly established. The dominant ram largely controlled the activity in the pen under most conditions, but became less effective in this regard when the number of ewes in heat increased. The presence of subordinate rams in a pen increased the total number of matings but reduced the average number of matings per ram below that of the pens containing only one ram. The average number of matings for the dominant ram in combination pens was just equal to the average number of matings in the single ram pens. The greater the dominance of one ram over another the less the total mating activity, especially the mating activity of the subordinate ram. Dominant rams were more successful in completing copulation than subordinate rams (6.3 versus 12.4 mounts per mating). Mature rams exhibited a greater degree of dominance over yearling rams and were more dominant over yearling rams than yearling rams were over other yearlings. Mature rams tended to be less dominant over other mature rams than yearlings were over yearlings.

In studying the mating behavior of the ewe it was found that ewes frequently initiated the first sexual contact by seeking out the ram. When two or more ewes were in heat simultaneously certain ewes would crowd other estrual ewes out of position in an attempt to gain the ram's attention. Means and standard deviations (in parentheses) for various mating behavior characteristics of the ewes were: times teased, 17.8 (7.0); times mounted, 25.2 (14.4); times mated 6.3 (3.8); matings first half of estrus, 3.9 (2.8); and matings second half of estrus 2.4 (1.7); hours first to last tease, 27.6 (13.9); hours first to last mount, 18.9 (8.5); hours first to last mating, 15.7 (9.1); hours first tease to first mount, 3.5 (6.8); hours last mount to last tease 5.0 (7.4).

Age had no significant effect on any of the above variables but was positively related to number of lambs born. The more highly inbred ewes had longer estrus periods than the less highly inbred ewes. The time interval from first tease to first mount was longer for the heavier ewes after accounting for association between age and weight. As the number of ewes in heat increased the numbers of teases, mountings, and matings per ewe declined as did hours from first to last mount, hours first to last mating, and matings first half of heat. Hours from last mount to last tease was the only mating behavior characteristic significantly correlated with number of lambs born. The times at which ewes exhibited first and last evidence of estrus appeared to be more closely associated with management routine than time of day per se. (AH b1-7)

3. Effects of the Light Environment on Reproductive Phenomena.

Effects of variation in the light environment on ovulation rate, embryo survival and gonadotrophic content of the pituitaries of mature ewes during the breeding season are being studied at Dubois, Idaho, in cooperation with Utah State University. Only preliminary results are available at this time.

The ewes were synchronized for estrus with intramuscular injections of progesterone in oil and subjected to continuous light, continuous dark or natural daylight (control) at about the time of the first post-treatment estrus. After 17 days half of the ewes in continuous dark were shifted to continuous light (dark-light) and half on continuous light were shifted to continuous dark (light-dark). The ewes were slaughtered at approximately 3 and 25 days gestation to obtain ovulation and embryo survival rates. There was some suggestion that continuous dark increased ovulation rate (2.21 per ewe) when compared to controls (2.08 per ewe). There was a strong indication that continuous dark increased embryo mortality (44.4%) when compared to the controls (22.2%). The dark-light sequence resulted in the lowest ovulation rate (1.84 per ewe) and the light-dark sequence resulted in the lowest embryo mortality (13.0%). No information is yet available on

pituitary gonadotrophins. This study is being continued. (AH b1-7)

4. Relation of Ovum Age to Ovum Recovery and Embryonic Age to Length of Embryo in Sheep.

The purpose of this study conducted at Dubois, Idaho, in cooperation with Utah State University was to determine the optimum time for most efficient ovum recovery in excised reproductive tracts, and to determine the effect of age on ovum recovery site and on embryo crown-rump length.

Percent recovery of ova related to time from first observation of heat to slaughter was: $2\frac{1}{2}$ days, 100%; 3 days, 88%; $3\frac{1}{2}$ days, 75%; 4 days, 66%; $4\frac{1}{2}$ days, 56%. The corresponding correlation was -.998. The percent of ova recovery from the oviducts of all ova recovered as related to time from first observation of heat to slaughter was: $2\frac{1}{2}$ days, 100%; 3 days, 95%; $3\frac{1}{2}$ days, 95%; 4 days, 76%; and $4\frac{1}{2}$ days, 0%.

The mean crown-rump length of embryos by age was: 23 days, 7.7 mm; 24 days, 7.9 mm; 25 days, 10.6 mm; 26 days, 11.2 mm; 27 days, 14.1 mm; 28 days, 15.4 mm; 29 days, 18.8 mm; 30 days, 20.0 mm; and 31 days, 21.8 mm. The corresponding correlation was 0.945. The regression of age on crown-rump length was $0.43 \pm 0.015$. Observations suggest that once embryo mortality occurs at this early age, degeneration is very rapid and is accompanied by marked change in the color, appearance and consistency of the embryo. The length of apparently abnormal but not degenerate embryos did not differ appreciably from those classified as normal. It is concluded that embryo crown-rump measurements can be used in obtaining relatively accurate estimates of embryo age but are less useful than appearance in judging embryo normality. (AH b1-7)

5. Synchronization of Estrus with Injected and Orally Active Progestins.

An attempt was made at Dubois, Idaho, to evaluate the effects of length of injection period (12, 15 & 18 days) and the kind of hormone (injected or oral) on degree of synchronization and post-treatment fertility. The intramascularly injected progestin was given at the rate of 10 mg per head per day. Sixty milligrams of the oral hormone was given per head per day for 14 days. These ewes were group fed.

The result indicates that the longer period of treatment (18 days) resulted in the best synchronization but the lowest fertility at the first post-treatment estrus (43.2% ewes lambing). The shortest injection interval (12 days) resulted in satisfactory synchronization and the best fertility at first post-treatment estrus (60.5% ewes lambing). The orally active progestin given in 1/2 pound of chopped grain

gave satisfactory sychronization with 61.4% of the ewes lambing to the first post-treatment estrus. The third post-treatment estrus was still fairly well synchronized and proved to be highly fertile in all treatment groups. The ewes were not mated at the second post-treatment estrus. (AH b1-7)

6. Natural Versus Electroejaculates for Predicting Fertility in Sheep.

It is a common practice to use the electroejaculator for collecting semen samples from rams for the purpose of predicting fertility. Heretofore no information has been available as to the relative merits of using naturally versus electrically ejaculated samples. An experiment was designed to make this comparison at Dubois, Idaho. The work was done in cooperation with Utah State University.

Preliminary results indicate that both semen quality and fertility predictability are somewhat higher for naturally ejaculated samples than for electrically ejaculated samples. This is probably due to the fact that ram response to electrical stimulation is extremely variable. Some samples closely approximate natural ejaculates, whereas other samples appear to be modified to varying degrees by accessory gland secretions. That is, the accessory glands are stimulated to secrete, but few, many or no sperm may be ejected from the ampulla and upper ductus deferens. A small percentage of samples are contaminated with urine. Also, the results suggest that the accessory glands and lower ductus deferens harbor degenerating sperm cells which upon electrical stimulation are flushed out in varying numbers by accessory gland secretion and appear in the ejaculate. The percentage of these cells relative to total cells is dependent to a large extent upon the number of sperm cells in the ampulla and upon the degree of evacuation. Thus, electrically ejaculated samples are lower on the average in concentration and motility and higher in pH and abnormalities than their naturally ejaculated counterparts. These results suggest that the electroejaculator should be used for semen testing only when natural ejaculation is impractical. When it is used the lower predictability should be understood and decisions made accordingly. (AH b1-7)

B. Environmental Physiology

1. Effect of Location on Productivity of Targhee Sheep.

Production data on Targhee sheep are being collected in Hawaii, at Dubois, and Moscow, Idaho; at Fort Wingate, New Mexico, and at Spooner, Wisconsin. Comparative data are available only at Beltsville at present. The Targhees were the most productive purebred sheep at Beltsville in 1961 as measured by the production index. The production indexes of the six breeds there were as follows: Targhee 79.0;

Columbia X Southdale 74.4, Southdown 71.2, Hampshire 71.1, Merino 61.8, and Shropshire 51.7. (AH b3-4)

2. Effect of Environmental Conditions at Four Different Geographic Locations on Fleece and Body Traits of Sheep.

The collection of data in the study to determine the effect of environmental conditions at four different geographic locations on fleece and body traits of sheep was completed during May, 1961. Data have been collected from Tifton, Georgia; Dubois, Idaho; Beltsville, Maryland; and University Park, New Mexico. Data are being summarized and analyzed.

Radioactivity determinations were made on fleeces grown at the four locations in 1959-60 in cooperation with the Agricultural Marketing Service and the U. S. Naval Hospital. High resolution gamma-ray spectrum measurements were made of individual fleeces, using an 8-in. diameter, 4-in. thick sodium iodide crystal detector. The scintillations produced were viewed by three 3-inch photomultiplier tubes, the output signal of which was fed into a 256-channel analyzer. The major gamma-ray emitter present in these grease wool fleeces was $K^{40}$. Since the suint or dried perspiration of the sheep is quite high in potassium content, $K^{40}$ gamma-ray measurements may provide an estimate of the suint content. $Cs^{137}$, a fission product, was also found to be present in many of the grease wool fleeces. The $Cs^{137}$ content of grease wool from individually fed rams from the four locations did not vary widely, with average values ranging from 17.7 to 22.5 gamma-ray emissions per second per pound. The group fed rams, which were fed feeds common to the location involved, showed large differences among the four locations, with average $Cs^{137}$ values ranging from 0.7 to 43.4 gamma-ray emissions per second per pound for wool sheared in the spring of 1960. These values were 0.7, 3.6, 9.2, and 43.4 for New Mexico, Maryland, Georgia, and Idaho, respectively. Grease wool obtained in the spring of 1959 from the same six rams that were group fed at the Idaho location in 1960 was also measured in the plastic scintillation detector. The $Cs^{137}$ content of 1959 grease wool from these rams averaged about twice as high for the spring of 1959 as for the spring of 1960. Thus measurement of grease wool fleeces may offer some unique advantages for surveillance of $Cs^{137}$ levels. An individual grease fleece may reflect the effect of one year's consumption by the sheep. With a suitable detector the level of $Cs^{137}$ gamma-ray emission can be determined nondestructively in a short time with no prior sample preparation required. (AH b3-8)

3. Effect of Light on Wool Composition.

Six Rambouillet rams were maintained at Beltsville in complete darkness from January 11 to March 17, 1961. A group of seven comparable

rams were kept as controls in normal daylight over the same period. The two lots of wool entirely grown and removed under the above conditions were tested for Electron Paramogentic Resonance at the Wool and Mohair Laboratory, Western Utilization Research and Development Division, Albany, California. No difference was found between wool grown normally and wool grown in the dark. (AH b3-5)

C. Physiology of Wool and Fiber

1. Development of Mohair Follicles in the Skin of Angora Goats.

Observations of mohair follicles in the skin of Angora goats of various ages from McGregor, Texas, are being continued at Beltsville, Maryland, for (1) the study of follicular group populations, (2) the proportion of immature and mature follicles in the skin of the newborn, and (3) the influence of season and age on the behavior of follicles. Studies of fetal Angora goat follicles have been completed. Ratios ranged from 7 to 10 secondaries for each primary follicle. Thus each group comprised 21 to 30 secondary follicles, plus three primary follicles.

It is interesting to note that the follicular population of South African Angora goats, obtained through the courtesy of Grootfontein College, and undoubtedly chosen from selected kids and Angora does, showed ranges quite similar to those found in Texas animals.

Ziehl-Neelsen's acid fast procedure has been adapted for staining skin sections and found to serve as an additional tool in differential counts of the primary and secondary follicles of sheep and goats. (AH b5-1)

2. Blood Supply to Fiber Follicles of Sheep and Goats.

Since follicular activity depends on a normal supply of blood to the skin, it is important to know just when the follicle obtains its direct supply through the dermal papilla. In dairy goats and Karakul sheep, blood capillaries enter the papillae of the primary follicles between 90 and 100 days of fetal life. In the Angora goat entry is somewhat later, beginning apparently on or about the 100th day. After this blood supply has been established, gradual keratinization of the primary follicles and fibers takes place. In follicles that develop later, entry of the blood capillaries occurs at a time when the follicular bulb is large enough to house at least one capillary loop. In the dairy goats, some of the very small secondary follicles may lack a direct blood supply. Studies of Merino, Rambouillet, and Hampshire sheep indicate that genetic potentialities of follicular anlage determine not only the type and density of the fibers produced and the type of glands that enable the skin to carry on the necessary

metabolic processes, but also determine the blood picture of the skin at a given age and during a given season. The blood vessels of sheep and goats are arranged in three main layers and branch into smaller arterioles, venules and capillaries in response to the demands of a growing follicular population. (AH b5-1)

3. Effect of Temperature on Wool Follicle Development.

In a preliminary experiment in cooperation with the Texas Agricultural Experiment Station, pregnant Merino ewes were kept for 11 hours daily at a temperature of 105° F. for at least the three last months of pregnancy, while the control animals were kept outdoors from August to October at McGregor, Texas. Lambs born smaller than usual and apparently in response to the heat treatment of their dams (although some lambs did not show any deviation from the norm) had large follicles and fibers with coarse medullation. This is contrary to the usual histological picture in Merino lambs. A small male lamb from a treated dam had only one mature secondary follicle in proportion to 10 immature follicles as compared to the ratio of about 1:1 in a larger lamb seemingly unaffected by the treatment to high temperature. (AH b5-1)

4. Effect of Season on Mohair Follicles.

Postnatal biopsies taken in 1959 at McGregor, Texas, and studied at Beltsville, Maryland, showed a relatively higher incidence of resting or shedding primary follicles and a lower incidence of medullated fibers during the colder months. Supported by similar observations made of material obtained in 1960 and 1961, this picture would indicate the influence of season on primary follicles. As a general rule, the primary follicles have medullated fibers at birth and some of these persist following the first shedding, as well as in the succeeding cycles throughout the life of the goat. (AH b5-5)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Physiology of Wool and Fiber

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## SHEEP AND GOATS - NUTRITION AND MANAGEMENT
Animal Husbandry Research Division, ARS

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

### USDA PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho; and College Station, Texas, in cooperation with other Divisions of ARS, and in formal and informal cooperation with State stations of Delaware, Idaho, Maryland, Montana, New York, Oklahoma, Texas, and Utah. Studies on ruminant bloat contribute to the North Central regional project on the chemistry and physiology of bloat.

The Federal scientific effort devoted to research in this area totals 3.7 professional man years. Of this number, 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.6 to range and pasture management, 0.1 to management practices, equipment and facilities, and 0.4 to program leadership.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 23.0 professional man years divided among sub-headings as follows: Digestion and metabolism 2.1, concentrates 3.0, forage evaluation and utili-

zation 5.2, nutrient requirements 4.4, range and pasture management 3.1, and management practices, equipment and facilities 5.2. This research is currently being conducted in all four of the regions with research in three regions being coordinated through W-34, S-45, NC-27, and NC-63 regional projects. Four States and USDA (informal) are cooperating in studies on nutrition of range sheep through regional project W-34. One State is investigating the nutritional evaluation of forages for fattening suckling lambs through the regional project S-45. Seven States and USDA are cooperating in studies of the chemistry and physiology of bloat through regional project NC-27. Eleven States and USDA are cooperating on studies of the biochemistry of forage utilization by cattle and sheep through regional project NC-63.

Basic studies of rumen function and the metabolism of products produced by rumen microbial activity are of major concern in the research of the State experiment stations. Investigations on concentrates are concerned with increasing the efficiency of sheep production by formulating suitable rations for fattening lambs and by devising economical rations for maintaining breeding ewes. Investigations on forage utilization are also concerned with efficiency of use as influenced by trace mineral supplementation, grazing systems, various perennial and annual forages, and by factors in the rumen concerned with forage digestion. The quantitative requirements for and the metabolism and interrelations of various minerals, proteins, and vitamins are being evaluated. The use of hormone, antibiotic, enzyme, or other feed additives in improving growth and feed efficiency is a very active area of study. The relation of nutrition to animal disorders such as "stiff lamb disease," nitrate poisoning, and trace mineral deficiencies is receiving attention. The effect of prenatal nutrition upon prenatal and postnatal development of the young is also under study. Intensive systems of management on pasture for spring lamb production, as well as the effects of range management practices on the range plants and the grazing animals, are important areas of study. Improvement of management and facilities are being studied by evaluation of early weaning, creep feeding, supplement for wintering ewes, varying weights of feeder lambs and equipment such as scales for chute sorting and self feeders.

Industry and other organizations conduct sheep and goat nutrition research mainly in the fields of feed additives and ration comparisons with particular emphasis on developing and testing new products. The estimated activity in this area amounts to 10 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism.

1. Metabolic Disorders.

Three sets of experiments were conducted at Amarillo and College Station, Texas, from the fall of 1958 to the spring of 1961.

A definite relationship existed between the dietary mineral intake and the occurrence of urolithiasis in fattening lambs. The addition of disodium phosphate to the basal diet proved to be calculogenic in all instances. The addition of calcium carbonate in the form of carbotex reduced the incidence of urolithiasis. Lambs fed diets high in potassium had less urolithiasis. A non-significant increase in the number of cases of urinary calculi was observed when either magnesium carbonate or steamed bone meal was added to the basal diet.

Results obtained from analyses of the blood and urine samples taken during the experiments indicated that changes in the dietary mineral balance significantly altered the mineral levels of the serum and the urine. Certain physiological relationships were observed between the dietary intake of calcium, phosphorus, and potassium and the serum and urine concentrations of calcium, phosphorus, and magnesium. The addition of disodium phosphate to the diet resulted in significantly higher levels of phosphorus in the serum and the urine. The increased concentrations of phosphorus in the serum and the urine were associated with a significant increase in the level of serum magnesium and a significant decrease in the urinary excretion of magnesium. Lambs receiving disodium phosphate in their diet had significantly lower levels of calcium in their serum.

The levels of serum phosphorus and magnesium were significantly decreased and the level of serum calcium significantly increased in lambs receiving diets high in calcium. Animals receiving the high-calcium diets had significantly lower levels of phosphorus in their urine.

Lambs fed the high potassium diets excreted larger amounts of magnesium in the urine which may have accounted for the lowered incidence of urolithiasis in these lambs.

A general reciprocal relationship existed between the urinary excretion of phosphorus and magnesium in these experiments. High phosphorus excretion in the urine was associated with a decreased urinary excretion of magnesium, and these conditions were apparently predisposing to urinary calculi formation.

The addition of ammonium chloride to the diet at a level of 0.5 oz. per animal per day reduced the incidence of urolithiasis. The prophylactic value of ammonium chloride in reducing the occurrence of urolithiasis was assumed to be due to the observed significant reduction in the urinary pH, which resulted in increased solubility of the phosphates. (AH b2-1)

Cooperative work on the physiological factors associated with ruminant bloat at Ithaca, New York, was terminated during 1961 due to transfer of the cooperating agent. Data are now being summarized and prepared for publication.

Cooperative work on the physiological and biochemical nature of ruminant bloat has been initiated with the Animal Husbandry and Dairy Departments of the University of Maryland. Forty-two cases of experimental bloat (39 in sheep, 2 in cattle, and 1 in goats) were produced by the simultaneous injection of the animals with a sympathetic nervous system stimulator and a parasympathetic nervous system inhibitor. Intensity of bloat varied from slight to severe. Experimental bloat also was produced by oral administration of L tyrosine.

Tyrosine in acid fermentations is readily decarboxylated to form the sympathomimetic drug tyramine. Other alkaloids existing in legumes are parasymatholytic. Preliminary work with fractional extracts of green alfalfa and ladino clover indicates that these fractions may be involved in the natural production of bloat. The parotid and submaxillary salivary ducts were ligated in sheep to determine the effect of limited salivary excretion on bloat production when animals are grazing on legumes. No bloat was produced in either the treated or control animals. (AH b2-6)

2. Feeding Practices and Procedures.

Data obtained during a 4-year period on the long-term effects of feeding pelleted diets to sheep at Beltsville are being summarized. The following conclusions appear to be warranted. Weight gains of animals receiving ad-lib alfalfa hay pellets are substantially greater than those of animals receiving chopped alfalfa hay ad-lib. The increased gains appear to result primarily from increased feed intake. Weight gains of animals on restricted intakes of pellets appear to be similar to those of animals receiving equivalent amounts of chopped hay. Animals receiving pellets ad-lib have not displayed depraved appetite symptoms but animals on restricted intakes of pellets have consistently displayed depraved appetites. Death losses of animals receiving pellets ad-lib have been excessive but death losses of animals receiving restricted levels of pellets have been similar to that of animals receiving chopped hay and normal diets. Rumen volumes of animals receiving pelleted diets are similar to those of animals

receiving chopped hay. Certain ruminal musculature, such as the pillars, are not as well developed in animals receiving pellets but no clear cut differences in ruminal motility have been established.

Gross symptoms of parakeratosis have been observed in only one year out of four. Histological data over a 2-year period, however, indicate that ruminal epithelium can be abnormal in pellet-consuming animals without gross symptoms of parakeratosis. Intensive histological studies conducted during the past year revealed very little normal epithelium in the forestomachs of self-fed pellet animals with all sections revealing a parakeratotic type of epithelium. Changes in the epithelium of the forestomachs of animals receiving restricted levels of pellets were even more advanced than those of the self-fed animals.

One hundred head of ewe lambs were used on a feeding trial comparing alfalfa hay pellets with long hay during the winter feeding period. An equal weight of pellets was fed in place of long hay to one-half of the animals. Both groups received grass silage in addition to the hay or pellets. During a 128-day period, the lambs receiving the pellets gained 0.26 pound per day, compared with 0.15 pound per day for the hay-fed lambs. There were no differences in the grease wool weights between the two groups as yearlings. In two previous trials with ram lambs, grease wool weights were increased by pellet feeding in addition to weight gains. The results of the 3-years work prove that pelleting of the hay for replacement breeding stock can either result in increased gains or reduced feed requirements during the wintering period. (AH b2-5)

In an attempt to find a more economical and time saving method of feeding sheep in the winter feed lots at Dubois, Idaho, and at the same time maintain the sheep in satisfactory breeding condition, 500 ewe lambs (Targhee, Columbia and Rambouillet breeds equally represented) were divided into five treatments and fed alfalfa as follows: lot 1 (control) fed 4.5 pounds baled hay on ground; lot 2, self-fed 5.2 pounds high-quality pellets (17% protein) from green, fine-stem hay; lot 3, self-fed 5.2 pounds low-quality pellets (13% protein) from brown, coarse-stem hay; lot 4, hand-fed 3.4 pounds of the high-quality hay pellets; and lot 5, hand-fed 3.4 pounds of the low-quality hay pellets. The lambs averaged 77 pounds body weight at the start of the 112-day feed trial and final weights were 99, 140, 133, 117, and 116 pounds for lots 1, 2, 3, 4, and 5, respectively. Ewe lambs self-fed high-quality pellets yielded grease fleece weights 1.6 pounds heavier than the control lambs. Apparent dry matter digestibility was 57.7, 61.4, and 54.9 percent for long hay, high-quality pellets and low-quality pellets, respectively, as determined from a digestion trial. This study was conducted again in a similar manner in 1962.

Forty-six ram lambs were used in total digestion trials during 1958, 1959, and 1960 to relate gain and feed efficiency data to the apparent digestibility of some nutrient constituents of the ration (7/8 alfalfa and 1/8 oats, pellet form). In 1960 two digestion trials were conducted. In trial 1, individual feed intakes were permitted to vary in accordance with previously established average daily ad libitum intakes. In trial 2, individual feed intakes were restricted to 3 pounds per 100 pounds body weight. Correlations between feed efficiency (pounds of feed consumed per pound of gain) and dry matter digestibility were -.45 and -.63 for trials 1 and 2, respectively. Digestible gross energy was correlated with feed efficiency -.58 and -.72 for trials 1 and 2, respectively. (AH b3-9)

During years of adequate rainfall thousands of lambs are fattened on wheat pasture in Oklahoma and adjoining areas. Previous work at the Fort Reno Station has shown that lush wheat pasture on fertile soil will carry about five lambs per acre. To investigate the possibility of increasing this carrying capacity and study the degree of finish in fattening lambs, 319 Western feeder lambs were self-fed a mixed ration while grazing wheat pasture. The lambs were divided into three groups by weight, below 62 pounds, 63-72 pounds, and above 72 pounds. Sorting the lambs into three weight groups and self-feeding a complete ration, in addition to the wheat pasture, appears to offer several advantages: (1) Unless the heavy lambs are started on feed immediately they may reach market weight without sufficient finish, (2) the stocking rate per acre can be increased considerably, (3) the lambs on self-feeders will continue to gain in weight during inclement weather and, (4) practically all lambs will sell at top market price.

The acreage of peanuts in Oklahoma has increased considerably in recent years. Volumes of peanut hulls are now available and it was felt desirable to test their value in replacing alfalfa hay in a lamb fattening ration. Indications were that peanut hulls can satisfactorily replace from 50 to 90 percent of the alfalfa hay in a lamb fattening ration if the peanut ration is nutritionally adequate in other respects.

Comparisons of different ratios of concentrates to roughage and the effect of pelleting also were made. Pelleting increased the average daily gain with a ration composed of 45 percent milo, 5 percent molasses, and 45 percent alfalfa hay, but a slight decrease in gain was noted in three other comparisons. Pelleting increased the amount of feed required per hundred weight of gain in three comparisons out of four. A feed with a concentrate to roughage ratio of 1:1 produced greater gains with less feed per hundred weight gain than a ratio of 65 percent concentrate and 35 percent roughage. (AH b3-7)

The feed consumption of 122 lambs receiving green chop ad-lib from April 12, 1961, through completion of weaning on June 28 was determined. Each lamb was allowed 0.83 pound of creep feed pellets per day and also allowed to nurse its dam from 4 p.m. until 8 a.m. daily. Winter wheat forage was used as the green chop from April 12 through May 6 and orchard grass-Ladino clover forage from May 7 through June 28. All material was weighed into the feeders and all refused feed was weighed back once a day. Samples of all feed given and all feed refused were taken on a daily basis for chemical analysis. The average consumption of dry matter was 1.0 pound, per lamb, per day, which was equivalent to 8.3 pounds of green forage. Data on the green chop consumption of lambs after weaning is being summarized. (AH b3-11)

3. Digestibility Studies.

A complete pelleted ration with chromic oxide included at 0.5% was fed to six sheep on an experiment of Latin square design at Beltsville, Maryland, in cooperation with the Beef Cattle Research Branch. Comparison of dry matter digestibility as determined by total collection, chromic oxide ratio, and lignin ratio methods, showed close agreement between coefficients determined by total collection and chromic oxide ratio methods; the lignin ratio method resulted in low coefficients. These results were obtained when total feces were collected from each sheep over 10-day periods. Coefficients determined from single-day feces samples by the chromic oxide ratio method agreed well with those obtained by the total collection method. The standard deviation of single day coefficients was only 1.10. Chromic oxide recovery during the experiment averaged 100.7%; lignin recovery 90.2%. (AH b2-5)

B. Forage Evaluation and Utilization.

Sixty-five head of ram lambs were used to compare the feeding value of pearl millet silage (corn meal used as a preservative) with corn silage at Newark, Delaware. Gains of the lambs during the winter feeding period were equal on the two silages. Digestion coefficients for the millet silage were: Dry matter, 62.7%; crude protein, 41.3%; ether extract 72.4%; crude fiber 66.9%; and NFE, 66.6%.

The digestibility of Ambercane silage was compared with corn silage in digestion experiments conducted at the University of Delaware with sheep, rabbits, and cattle. Nutrients in Ambercane silage were less digestible than those in corn silage. The correlation found between silage crude protein content and digestible protein content was $r = 0.75$. Digestion coefficients were significantly correlated between rabbits and sheep for both silage dry matter and protein ($r = 0.98$ and $r = 0.93$, respectively). (AH b2-7)

The digestibility of sun dried and artificially dried crown vetch was compared with No. 2 alfalfa hay in a digestion trial experiment with sheep at Beltsville, Maryland. The TDN content on a 90% dry matter basis was 48.8, 41.0, and 44.6%, respectively, for the alfalfa hay, sun dried crown vetch and artificially dried crown vetch. (AH b2-8)

A comparative study was made of the in vitro digestibility of different forage species considered to be a major part of the diet of sheep on the U. S. Sheep Experiment Station summer range at Dubois, Idaho. Forage species included were slender wheatgrass, mountain bromegrass, sedgegrass, wild aster, wild dandelion, sticky weed, wild carrot, lupine, sweet anis, and one-flowered sunflower, which were separately fermented with buffered sheep rumen inoculum. Proximate analyses were conducted before and after fermentation and changes in composition reflected the effects of digestion by rumen micro-organisms. Total volatile organic acid production was also determined. The results showed that with the exception of wild carrot, all forbs were higher in crude protein than grasses. No consistent difference was found between forbs and grasses in ether extract and nitrogen-free extract. The crude fiber content of grasses was above that found in forbs. The losses as a result of fermentation of crude protein, nitrogen-free extract, and dry matter were greatest from the forb species. Losses of crude fiber were not consistently different in grasses and forbs. Ether extract was observed to increase during fermentation for all species except the one-flowered sunflower. No definite relationship was indicated between the amounts of volatile organic acids produced and other factors studied. Quantity and quality of the nutrient intake of sheep grazing on the U. S. Sheep Experiment Station summer range are being investigated by the use of esophageal fistulated sheep and bagged sheep for total feces collection. Digestion trials are being conducted at early, intermediate, and late periods of the summer season. (AH b3-9)

C. Range and Pasture Management.

1. Range Management.

A range survey, initiated in 1959 on the U. S. Sheep Experiment Station summer range near Dubois, Idaho, was completed in 1961. A grazing management plan for the Station's summer range was developed from this survey and put into operation. Statistical analyses have continued on the survey data. Phenology, soil movement, and weather observation studies will be continued and grazing exclosures will be maintained. This work is being carried on in cooperation with the Intermountain Forest and Range Experiment Station and the University of Idaho.

Summer grazing studies in four 80 acre pastures on the Station spring-fall range were continued with ewes that had produced Hampshire X Whiteface lambs. The stocking rate was increased from 23 and 36 sheep days

per acre to 28 and 45. The average loss in body weight from July 3 to September 17 was 15 and 22 pounds per ewe, respectively. Forty-two percent of the available forage was utilized on the three major grasses in the pastures with the lower stocking rate and 68 percent at the higher stocking rate. The black-faced lambs were creep fed a grain-hay-molasses pellet from birth to weaning (July 3) at which time the average age was 87 days. After weaning, the lambs were self-fed pellets (as above) and topped and marketed in three groups at three week intervals. Individual weights, dressing percent, and carcass grades were obtained. In an attempt to produce a more uniform age lamb crop, the ewes were synchronized with progesterone and mated to Columbia, Targhee, Hampshire, and Suffolk rams in the fall of 1961. Grazing rate will remain the same in 1962 but the lambs will not be weaned as early, so will be placed in the study pastures with the ewes for part of the summer trial.

Methods of grazing management with sheep to permit optimum use of the spring, fall, summer and winter ranges are being investigated at the U. S. Sheep Experiment Station, Dubois, Idaho. Sagebrush-grass range has been improved by grazing management with no reduction in stocking. Spring rest with heavy fall grazing by sheep resulted in less sagebrush and more grass and other herbage.

Rotation grazing at 20 and 40 sheep days per acre was studied on sagebrush-grass range at the U. S. Sheep Experiment Station from 1940 through 1958. Half the use was in the spring and half in the fall at both rates. The highest rate of rotation grazing tested in this study did not damage the range. However, previous work indicates that this rate would have caused the range to deteriorate if the grazing had been continuous or at the same time each spring. Rotation grazing allowed heavier utilization of forage than is possible with continuous grazing. (AH b3-1)

One of the objectives for the high summer range management investigations is to determine the grazing habits and utilization of forages by non-herded compared to herded sheep. Weaning body weights of non-herded lambs were 10 and 8 pounds lighter than herded lambs on similar range during the 1960 and 1961 summer grazing seasons. The pasture lambs also had poorer type and condition scores and shorter staple length. The lower production of the pasture flock may be explained in part by their failure to move to better forage when not herded. These estimates are independent of type of mating, sex, type of birth and rearing, age of dam, days growth, and band in which they grazed.

Bi-weekly weights were taken on the non-herded flock in order to gain more information on growth curves of range lambs to aid in management. Eighty-two percent of the final weaning body weight was reached on the sagebrush-grass spring range before the lambs were moved to the high

summer range. Lamb body weights averaged 62 pounds on July 10 and 76 pounds at weaning time August 23. (AH b3-9)

2. Grazing Practices.

Studies on the effects of grazing sheep and cattle together have been continued at Beltsville. These studies are being carried out in cooperation between the Sheep and Fur Animal Research Branch, Beef Cattle Research Branch, and the Forage and Range Research Branch of the Crops Research Division. An orchard grass-Ladino clover pasture was laid out in 1961 in two replicates, each made up as follows: Lot 1 (1-1/2 acres) grazed by 2 beef steers; lot 2 (3 acres) grazed by two steers and 10 sheep; lot 3 (1-1/2 acres) grazed by 10 sheep; lot 4 (1-1/2 acres) grazed by 2 steers and 2 sheep; lot 5 (1-1/2 acres) grazed by 3 steers; lot 6 (3 acres) grazed by 3 steers and 15 sheep; lot 7 (1-1/2 acres) grazed by 15 sheep; and lot 8 (1-1/2 acres) grazed by 3 steers and 3 sheep. The animals were placed on experiment on May 1, 1961, and were on test for 163 days. One animal unit was removed from each pasture on June 23 because of overgrazing in the heavily stocked lots. The data indicated that the lower stocking rate was better than the higher level; that animal performance was better for the steers and sheep grazing together (1:5) than for the animals grazing separately; and that the animal performance was poorest in the lots with steers and sheep grazing together in a 1:1 ratio. Due to drought conditions during 1962, the data are too limited to warrant any conclusions. (AH b3-10)

3. Management in Relationship to Parasitism.

Studies on the effect of management practices in relationship to parasitism and gains of lambs have been continued at Beltsville. These studies have been conducted in cooperation with Animal Disease and Parasite Research Division. Four management systems were studied in 1961. The systems included; I, ad lib feeding of green chop to lambs in dry-lot; II, transfer of animals to a clean pasture at bi-weekly intervals; III, grazing of animals on contaminated pastures, plus therapeutic treatment with N.F. phenothiazine; and IV, grazing of animals on contaminated pastures, plus therapeutic treatment with purified phenothiazine. Lambs on treatments II, III, and IV were supplied with creep pellets ad lib until weaning while creep feed was limited for treatment I to that consumed by the pasture lambs. Average daily gains from April 12 through weaning were 0.45, 0.46, 0.37, and 0.39 lb. per day, respectively, for the four treatments. Observations on replacement lambs following weaning indicated that parasitism was insignificant in lambs on treatment I, light to moderate in lambs on treatment II, very heavy in lambs on treatment III, and heavy in lambs on treatment IV. Four management systems were also studied in 1962. These included, I, ad lib feeding of pellets to lambs in dry-lot;

II, pasturing of lambs on clean pasture separately from the ewes (lambs were allowed to nurse at night in dry-lot); III, grazing of animals on contaminated pastures, plus therapeutic treatment with purified phenothiazine; and IV, grazing of animals on contaminated pastures, plus therapeutic treatment with thiobendazole. Average daily gains from April 14 through weaning were 0.60, 0.53, 0.58, and 0.52 lb. per day, respectively, for the four treatments. Data to date indicates that parasitism is heaviest under system IV. (AH b3-11)

D. Management Practices, Equipment, and Facilities.

1. Lamb Mortality.

Studies on lamb mortality at Beltsville, Maryland, were discontinued at the end of the 1961 season. Lamb mortality during 1961 was 5.8% for the first 14 days following birth of the lambs. Abortions accounted for 6.5% of the losses, still-born lambs for 41.9%, and death losses during the first two weeks for 51.6%. Sixty-two percent of the lambs that died were from multiple births. Lamb mortality during the 1961 season was 65% lower than during the 1956 and 1957 seasons. This marked reduction has resulted principally from improved nutrition of the ewes during gestation and adequate attention to the ewes and lambs during lambing. (AH b3-6)

2. Purchased vs. Raised Replacement Ewes.

To study lamb and wool production of purchased versus raised replacement ewes under Southwest conditions, three groups of ewes were started on test at the Fort Reno Experiment Station during the springs of 1957, 1958, and 1959. Each group was composed of four breeding groups, two of which were raised and two of which were purchased. The first 20 ewe lambs to reach market weight (90 pounds) from both 1/4 Panama X 3/4 Rambouillet ewes, and straight bred Rambouillet ewes constituted the raised replacements. Both groups were sired by Dorset rams. The purchased ewes were two groups of 20 each of Southwest white-faced yearling ewes and were selected to represent the kind of purchased replacements usually available. Preliminary conclusions are as follows: The purchased ewes produced more fall born lambs during the first year of production but decreased thereafter. The one-half Dorset replacement ewes producing their second and later lamb crops displayed a greater tendency for both fall and winter lambing than comparable Western ewes. Western ewes that were part Columbia or Panama produced fewer fall lambs but more winter lambs than Rambouillet ewes. There was little or no difference in the birth weight or early rate of gain (birth to 50 lb.) of lambs produced by the raised or purchased ewes. The purchased ewes sheared more grease wool than the raised ewes, but the clean wool production was about the same. Mortality was higher among the raised ewes than among the purchased ewes. (AH b3-7)

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## PRODUCTION INFLUENCES ON ANIMAL PRODUCTS
Animal Husbandry Research Division, ARS

Problem. Pork, beef and lamb meat are excellent protein foods and most American diets are built around them. However, these meats are each criticized by the consumer for too much fat covering, lack of a bright red color, tenderness and flavor. The choice cuts and kind of meat are directly reflected in the demand and in the price of the product. Similarly, milk, eggs, poultry meat, wool and fur are demanded by the public in a high relationship to the desirability of their traits whether they be nutritive or functional. Many of the production practices directly affect the characteristics of animal products. Breed differences in butterfat and color of milk, nutritional effects on color of egg yolk, environmental stress on strength of wool, castration effects on flavor, color and tenderness of meat are well known production influences on animal products. Many other effects of production practices, however, are not so well understood but may be of considerable economic importance. Effective measures of evaluating quality and quantity differences are very important parts of this effort.

### USDA PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will aid in livestock production. Research on beef, veal, lamb and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. Research on humane slaughter was initiated to develop information and techniques on preslaughter handling, restraining, immobilizing, and dispatching of hogs, cattle, and sheep, in order to determine the most effective procedures for meeting the requirements of the humane slaughtering law and the influence of the effect of these procedures on the quality of the meat. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; and in cooperation with eight State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the

Human Nutrition Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 16.4 professional man-years. Of this number 5.4 are devoted to beef, 1.3 to lamb, mutton, and chevon, 4.0 to pork, 1.0 to poultry and eggs, 1.7 to wool, fur, and fiber, 1.6 to humane slaughter, and 1.4 to program leadership.

Contract studies were completed during the year with the State Experiment Stations of Nebraska and South Dakota. The work in Nebraska was initiated to study relationships of certain live animal and carcass characteristics. At South Dakota the studies estimated the genetic and phenotypic relationships of carcass characteristics, growth, and conformation traits. Each of these studies constituted funds equivalent to .1 professional man-years.

A contract is in progress with the Wyoming State Experiment Station regarding the evaluation of lamb carcasses. Funds supporting this contract amount to .2 professional man-years.

A grant with the Polish Academy of Sciences in Poland provides for studies on the color of pork as influenced by heredity, sex, age, feeding, and management. Its duration is for five years (1960-1964) and involves PL 480 funds with $42,784 equivalent in Polish zlotys.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations reported a total of 17.9 professional man-years of which 7.7 are on studies relating to beef, 3.1 lamb, mutton, and chevon, 2.8 pork, and 4.3 poultry and eggs. Comparisons are being made of grass fattening, drylot fattening, or combinations of these, as influences on carcasses and meat characteristics. Studies are being conducted on varying the length of heavy silage feeding preceding finishing with a high energy ration, creep feeding versus no creep feeding during the nursing period, and various combinations of ration ingredients with and without adjuvants. Research is in progress on the influence of ratios of protein to energy and total feed consumption on carcass characteristics of swine. Still other studies are on the evaluation of various criteria of selection for superior meat type swine. Research on egg quality includes work on the causes and prevention of blood and meat spots and undesirable yolk coloration. The effects of different egg washing techniques on interior quality are also being evaluated. Studies have been undertaken on the effect of nutrition and management on chicken and turkey carcass traits, such as skin pigmentation and a desirable amount of fat. A number of breeding projects contributing to regional research projects are designed to determine the effectiveness of selection and improving carcass

traits and the effect which selection of one carcass trait has on other carcass traits. Several stations are studying the pattern of growth in different breeds and crosses of sheep as affected by feed, sex, castration and type of birth.

The activity by industry in the field of animal products is generally in the field of product processing and marketing. There are a few studies regarding the influence of production practices on product characteristics. One of the larger packing companies is carrying out an extensive beef improvement program including evaluation of carcasses for production of muscling, absence of waste, desirable ratio of fat to lean, and tenderness. Also, the packing industry cooperates extensively with publicly supported experiment stations in the grading and evaluation of carcasses resulting from various nutrition and management studies. Several textile mills conduct work on wool traits in sheep, including clean yield, fiber diameter and fiber strength. The number of professional man-years involved in industry effort on this area is estimated as 4.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Lamb

#### 1. Tenderness.

The trained panel evaluation and the Warner-Bratzler tenderness testing machine are being used in all the studies. During the report period 78 lamb leg samples were tested for palatability. These were representative lambs resulting from the one, two and three breed crosses, and the purebred parent breeds. Tenderness differences were the most striking of all organoleptic characteristics studied. With the exception of one very tough lamb sample, which received a panel rating of 1.6 (very tough) the range was from 6.6 (very tender) to 3.0 (tough). The tenderness average was 4.8 (moderately tender) with a sample standard deviation of 0.91. The variability in tenderness scores was large and suggested a real tenderness problem among the lambs slaughtered. (AH b6-1)

#### 2. Composition.

Ultrasonic measurements of fat and lean depth of 78 lambs from last year were analyzed to study live animal composition. Analysis revealed that ultrasonics were more effective in determining carcass weights and leg weights than in estimating carcass composition. The estimated depth to the bone (thickness of loin eye) over the last rib of the live lamb was definitely related to the carcass weight and trimmed and untrimmed leg weights when slaughtered weight was held constant. Additional ultrasonic readings are being obtained this year.

These consist of readings of fat and lean thickness at one, two and three inches off the midline over the last rib on the right side. (BS 3-34)

Different chemical procedures for evaluating chemical composition of the lamb carcass were compared using 70 lambs. These analyses consisted of ether extract fat of (1) the left rib eye muscle, (2) remaining edible of the rib, (3) ground samples consisting of fat, lean and bone from the right half rib, right leg and remaining cuts of the right side composited as one. A statistical analysis of the data shows that the chemical analysis of the rib sample was significantly correlated with the other method (ground up whole). However, a chemical analysis of the whole leg was the most accurate predictor of a chemical analysis of the total ground side. Chemical analysis of the rib sample was a better measure of carcass composition than physical separation, but the small increase in accuracy does not appear to be justified. (AH b6-1)

3. Carcass Evaluation.

A statistical analysis of the data from 1138 lambs is nearly completed. Relationships among carcass weight, measurements, yields and composition of the rib were analyzed, to determine which of these factors were most important and could be used in determining carcass yield and composition. Carcass weight, body width and either leg circumference or plumpness index were the most important of the 13 carcass factors studied to determine carcass yield. There was no significant increase in accuracy of determining carcass yield by using more than these three factors. Live weight at slaughter was also a reliable estimator of carcass yield. Using an estimating equation developed from the above information it was found that the correlation between the estimated and actual yield of 174 lambs slaughtered during the year was .80. (AH b6-1)

A statistical analysis of data from Dubois, Idaho, shows that the simple correlation between loin eye area and cannon bone circumference was .49, but the apparent association appears to be due to body or carcass weight. The correlation between leg width of the live lamb and that of the carcass was .82. Each of these measurements was relatively highly correlated with other carcass measurements. Carcass leg width was more highly correlated with the other carcass measurements studied than the leg width of the live animal. These results are in agreement with those obtained with the Beltsville lamb data. (AH b6-3)

4. Breeding as it Affects Carcass Quality.

Data on the last group of ram lambs produced from breeding experiments at the U. S. Sheep Laboratory, Dubois, Idaho, and slaughtered at the University of Wyoming have been obtained. Rambouillet lambs averaged lower in both slaughter and carcass grade all three years, with little difference between Targhee and Columbia lambs. Rambouillets had a lower yield of separable fat in the rib than the other two and had larger areas of eye muscle. Differences in composition were more apparent between years than between breeds. In 1959, both yields and composition were decidedly superior to these same factors in either 1960 or 1961. Within years, differences between breeds in both yields and composition were small and require statistical verification. (AH b6-3)

B. Wool and Fiber

1. Factors Affecting Quality and Value of Wool.

Fleeces from 24 Columbia ewes selected because of their coarse wool at weaning age in 1957 were studied throughout their lifetime at Dubois, Idaho, in informal cooperation with regional project WM-23, Marketing of Western Wools. Quality traits and processing characteristics of the fleeces were studied to determine their desirability as Columbia fleeces and to follow changes in subsequent years. Fleeces on the coarse wool Columbia ewes became coarser from 2 to 3 to 4 years of age. Fibers from the thigh area were coarser than those from the side by 3.0, 3.3, 2.7 and 2.8 microns for each of the 4 ages, respectively. Weight of grease wool, clean wool, and top increased to the third year and then declined slightly for the fourth year of age. Diameter and length of fiber in the top increased over the 4 years of age. A control lot of 24 Columbia ewes with finer fleeces and which had acceptable wool fineness for Columbias at weaning age were also studied over 4 years of age. The control fleeces also became coarser from one to 4 years but slightly less than the coarse fleeces.

Investigation of the relationship between quality traits and the economic returns from wool at Dubois, Idaho, was continued in 1961. The 64/70's quality fleeces were classed into three lots and 60/62's into two lots according to length of staple. One lot each of 56/58's, 50/54's, and 46/48's quality fleeces was studied. Average fiber diameter, staple length, clean fiber content and vegetable material were determined for each lot. The fleeces classed as 64/70's average French and the 60/62's French made lots too small to be useful for price comparisons. Two variable grade lots (control lots) were made up, tested for quality traits and clean fiber content and sold as original bag wool. Graded lines sold for 45.0 to 50.5 cents per grease pound. Wools of uniform quality sold for 3.25 cents more per pound than variable grade lines and fine staple wool sold for 3.75

cents more than fine French wool. Crutchings and shearing pieces from the fleeces making up the graded lines were mill scoured and yielded a clean fiber content of 41.2%. This wool sold for 31.4 cents per pound on grease basis.

To determine the importance of the relationship of lamb birthcoat to other fleece and body traits, birthcoats of 2534 Rambouillet, Targhee and Columbia lambs were scored (1 to 5) for the amount of hair-like fibers and for the amount of wool fibers present. Correlations were computed (holding constant sex, breed, type of birth and rearing, age of dam and days of age) between hair and wool scores and birth weight, weaning traits (staple length, bodyweight and belly wool) and yearling traits (staple length, bodyweight, belly wool, grease fleece weight, clean fleece weight, side and thigh grades). In addition, correlations were computed between the birthcoat scores and fleece grade, fleece value, uniformity of length and grade, and components of the sorted fleece (main sort, other sorts and off-sorts). Correlations (-.14 to 0.14) between hair score at birth and the other wool and body traits studied were low and unimportant, although, some were statistically significant. Correlations (-.21 to 0.24) between wool score at birth and the other wool and body traits studied were slightly higher in most instances than those between hair score at birth and the other wool and body traits. These results indicate that the amount of hair-like fibers and wool fibers in the birthcoat as determined by the scoring technique used has little or no relationship to future bodyweight or to the quality or quantity of wool produced. (AH b5-2)

2. Measuring Method to Evaluate Wool.

At Beltsville, Maryland, a crimp scale has been designed to facilitate the measurement and recording of width/depth ratio and number of crimps per inch. Interlaboratory tests are now underway to test the feasibility of using the scale to measure crimp in grease staples. It is necessary to determine if the scale is practical and whether laboratories can classify crimp from various samples of wool by use of this scale. If the scale and method seem feasible, additional testing for corroboration will be conducted.

A method was developed for measuring fiber length with the Wool Industries Research Association machine. Individual fiber length was measured in four wool grades by ruler and by the WIRA method. Two operators measured unstretched and stretched length by ruler and duplicate lengths by WIRA. Each operator pulled and measured two fibers from each of two levels (1/3 and 2/3 from the base) of each of 25 locks for each grade and also measured those pulled by the other operator. Analyses of variance with variance component esti-

mates, expected standard errors, and certain means, were computed separately for each grade. Although variance component estimates were generally larger for stretched than for unstretched measurements there was little difference between the methods expressed as percent of the total or as percent standard error of the mean. Average WIRA measurements, their variance component estimates, and standard errors of the means agreed more closely with stretched than with unstretched ruler measurements for all grades. Standard errors as a percent of the mean were larger for the WIRA than for either ruler measurement. Differences among pulling operators, levels and their interactions were generally small and insignificant. Measuring operators differed significantly and interacted with the ruler vs. WIRA classification. Their differences were larger with the ruler but still existed with the WIRA. WIRA measurements recorded to 0.5 cm. seem to contain considerable rounding error. A method of measuring fiber length with the WIRA developed from this study involves two operators, each pulling and measuring 8 fibers from one level of each of 50 representative locks from a lot or fleece.

Research is being conducted on the possibility of adapting the Coulter Counter for use in measuring the fineness and variability of wool fibers. The instrument is an electronic particle-size counter. Studies were conducted in cooperation with personnel of the Market Quality Research Division, AMS. Satisfactory results, comparable to those obtained by the standard method of the American Society for Testing Materials, have been obtained on certain wool top samples with this instrument. Problems were encountered with changes in temperature of the electrolyte affecting results through changes in the voltage drop across the aperture, improper stirring of the solution and fibers, and blockage of the aperture tube. A more refined and efficient model of the Coulter Counter is now being tested at Beltsville.

The standard method of determining fiber diameter and distribution is time-consuming and tedious, since the fibers lie at various angles on the slide, making it necessary to rotate the wedge scale considerably in order to measure each fiber properly. To develop a means of aligning the fibers for greater ease and speed of measurement, an electrostatic fiber alignment device was produced by the Special Instruments Laboratory, Knoxville, Tennessee, working with the U. S. D. A., Sheep and Fur Animal Research Branch, Beltsville, Maryland.

In order to use the device, the operator prepared a slide in accordance with standard specifications of the American Society for Testing Materials up to the mounting of the fibers. The fiber pieces are dispersed in an immersion oil and the cover slip is placed in position.

The slide is then placed in the slide holder which is inserted in the device. The cover plate is placed on the device and the fibers begin to align immediately. Alignment is completed and the medium sets sufficiently while a second slide is being prepared. Measurements are then made and recorded as outlined in the ASTM standard. Fiber dispersion is considerably improved with few, if any, intersecting fibers, when the alignment device is used with this immersion oil. For visual measurement by the microprojection method, alignment of the wool fibers lessens the number of movements of the wedge scale in determining the fiber diameter, thereby increasing the operator's speed in measurement.

Gamma-ray measurements were made of wool in cooperation with the Agricultural Marketing Service at Beltsville, Maryland, to study the relationship of gamma-ray emission of grease wool to the foreign matter content. The potassium contents of the grease wool fleeces were estimated from the $K^{40}$ gamma-rays and were found to vary widely. Since the suint (dried perspiration) is high in potassium, variations in grease wool potassium may reflect variations in suint content which are related to individual fluctuations in the amount and type of feed consumed. Scouring removed the bulk of the potassium present in grease wool. The variability of the potassium level found in scoured wool, ranging from 0.15 to 0.46%, suggests that potassium might be present in impurities which were not removed in the scouring procedure used in this study. $Cs^{137}$ values for scoured wool were usually much lower than for grease wool, ranging from 1.6 to 4.4 gamma-ray emissions per second per pound. In general, $Cs^{137}$ levels in scoured wool tended to reflect the levels present before scouring. The estimated potassium content and $Cs^{137}$ gamma-ray emission rate did not appear to be closely related to the total content of impurities present in the grease wool fleeces studied. Further work involving fractionation to determine the actual suint content is needed to determine if $K^{40}$ gamma-ray measurements can provide a useful estimate of total suint content. The gamma-ray measurement technique for estimating potassium content of whole fleeces may also be very useful in potassium balance studies. (AH b5-3)

3. Effect of Pregnancy and Lactation on Wool Production.

The problem of selecting mature ewes on the basis of wool production is nearly always confounded with lamb production. That is, those ewes that wean the most pounds of lamb probably produce the least amount of wool. This problem dealing with the effect of pregnancy and lactation on wool production has been investigated at the Fort Wingate Station. The least squares analysis included grease fleece weights for five years, 1955-1959, from 2241 ewes of all ages, from 7 breeding groups and included all 18 possible pregnancy-lactation groups. The study shows that ewes which gave birth to twins, weaned

twins and then became pregnant with twins again produced fleeces which averaged only 6.47 pounds. Ewes which were dry during the summer and then failed to become pregnant sheared an average of 8.00 pounds of wool. Ewes that weaned a lamb or lambs but were dry the following fall and winter sheared 7.41 pounds of wool compared to 7.80 pounds of wool for ewes that were dry during the summer but became pregnant during the fall. This probably indicates that lactation has a greater effect on wool production than does pregnancy. (AH b5-6)

4. Relation of Fleece Traits to Processing Characteristics.

Preliminary results have been obtained at Beltsville on studies of the relationship of carding and combing to inherent differences in wool. This study was designed to determine whether observed variations between grades of wool are due to inherent differences in the wool, to differences in machinery settings normally used in the processing of these different grades of wool or to a combination of these factors. Such information is essential in interpreting data obtained from carding and combing individual fleeces. The data which have been analyzed include weights and yields of card sliver, top and noils. Three separate analyses gave the following information: In analysis 1, fine wool and 1/2 blood wool carded with medium settings on the carding machine showed no statistical difference; with fine settings there was a highly significant difference in card yield. In analysis 2, 1/2 blood, 3/8 blood and 1/4 blood wools showed no differences with coarse settings but were significantly different with medium settings; and in analysis 3, 1/2 blood wool showed no differences with medium or coarse settings, but highly significant differences with fine settings. More detailed analysis of these data is necessary since the preliminary analyses indicate that significant differences in card yields are correlated with carding machine settings. From the same three analyses, highly significant differences were obtained for all grades of wool top and noil yields when the gauge setting which controls noilage was altered. Therefore, the amount of noils is more directly controlled by setting of the comb than by grade of wool.

Fourteen grade-breed lots from Dubois, Idaho, each containing 15 mature ewe fleeces visually grading the same, were studied to investigate further relationships among quality traits of grease wool to processing characteristics, yield and quality of top. Each grade-breed lot was sampled in the grease, scoured at the University of Wyoming Wool Laboratory and processed into top at Philadelphia Textile Institute. Data from the first year indicate that as the fiber diameter of grease wool increases within a breed, staple length increases, number of crimps per inch decreases, grease fleece weight increases, clean yield becomes higher, top yield per pound of clean wool increases, and variability of both fiber length and diameter in the top becomes greater. Columbia wool was slightly longer, had fewer crimps per inch, and was coarser than Targhee wool of the same visual grade. Targhee wool was longer, had fewer crimps per inch and was coarser than Rambouillet wool of the same visual grade. (AH b5-7)

PUBLICATION REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Lamb

Hiner, Richard L., and Thornton, John W. 1962. Study of certain lamb and carcass quality factors. Journal of Animal Science, 21(3), pp. 511-515.

## INFECTIOUS AND NON-INFECTIOUS DISEASES OF SHEEP AND GOATS
Animal Disease and Parasite Research Division, ARS

Problem. There are at least 18 infectious diseases of sheep and goats in the United States that cause an estimated annual loss of 15 million dollars. Non-infectious diseases are estimated to cause an additional 3 million dollar loss annually. The cause of some of these diseases is known; others have more than one causative agent contributing to produce the effects seen in field cases. Environmental, genetic, and unknown factors appear to play a part in some diseases. The natural reservoirs of the known infectious agents have not been fully determined. Fundamental information on methods of transmission and means of prevention are needed for many of these diseases. Vaccines and other immunizing products are available for some diseases of sheep but not for others. Some of these products might be improved. Prevention, control, or eradication of disease is necessary for economic and efficient sheep and goat raising. Due to lack of accurate, rapid diagnostic techniques, infectious diseases often get a substantial start in a band or flock before they are recognized, partly because they are easily confused with non-infectious diseases.

### USDA PROGRAM

The Department has a continuous long-term program involving biochemists, microbiologists, pathologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of infectious and non-infectious diseases of sheep and goats. Research is being conducted on the diseases at the following designated locations.

The Federal scientific effort devoted to research in this area totals 6.6 professional man-years. This effort is applied as follows:

Bluetongue, 2.0 at the Denver Animal Research Laboratory, Denver, Colorado.

Contagious Ecthyma, 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Foot Rot, 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Scrapie, 0.2 at the Agricultural Research Council Field Station, Compton, Berkshire, England, and the Moredun Institute, Edinburgh, Scotland, through two grants of P.L. 480 funds, equivalent to $300,165. The work is coordinated through the European Mission for Research on Animal Diseases, Amsterdam, Holland.

Vibriosis, 0.3 under cooperative agreements with the Colorado, Montana, and Utah Agricultural Experiment Stations.

Viral Ulcerative Dermatosis, 0.1 through a cooperative agreement with the Colorado Agricultural Experiment Station.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 11.3 professional man-years divided among subheadings as follows: (a) Vibriosis 5.6, (b) Scrapie 0.2, (c) Bluetongue 0.5, (d) Other diseases (pneumonia, mastitis, caseous lymphadenitis, listeriosis, etc.) 5.0. Regional research project W-27, Vibriosis in sheep, coordinates investigations on vibriosis of sheep between six western states and the USDA. Studies are being made at Indiana on scrapie. California, Texas, and Washington are working on bluetongue. California and Ohio are conducting research on the cause and prevention of pneumonia in lambs. Montana is studying the causes of mastitis in ewes and developing practical methods for control, and has work under way to identify the cause of balanoposthitis in rams and to develop procedures suitable for its control. Caseous lymphadenitis-its cause and prevention- and improved treatments for pregnancy disease of sheep are research objectives at Missouri. Nebraska and North Dakota are elucidating factors which contribute to outbreaks of listeriosis in sheep. South Dakota and Wyoming are working on the cause and prevention of urinary calculi in sheep. California is studying the cause and prevention of encephalomalacia in lambs and the significance of eperythrozoonosis of sheep.

Industry and other organizations are engaged in the preparation of marketable biologic and pharmaceutical products. They conduct experimentation on vaccines and the formulation of chemical compounds and other medicinal substances for prevention and treatment of diseases of sheep and goats. These companies generally will utilize their own facilities. Information gained in their research generally is confidential in nature as are expenditures for research and development. It is estimated that 20 p.m.y. are devoted to this work by industry and other organizations.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Bluetongue

In 1961, at the ADP Denver Laboratory, sheep blood samples were tested, representing suspected bluetongue (BT) outbreaks in 11 flocks from 4 States in which 6 flocks from 3 States were found to be infected. Bovine blood samples of 38 herds from 6 States were tested for BT virus, with isolation from 3 calves in a Utah herd, and 1 calf in an Idaho herd. These virus isolates were typed in sheep and found to be of the same immunogenic type as our standard BT virus.

Two of 3 mature goats, inoculated with known virulent BT virus, showed no clinical symptoms or febrile response to the disease. The third goat, although showing no clinical symptoms, did show a febrile response from post-inoculation days 9 to 12. All three goats withstood challenge with the homologous virus.

Sheep inoculated with 17th, 30th, and 40th serial passage tissue culture virus developed an immunity to the disease as evidenced by challenge with known virulent BT virus and tissue culture serum neutralization tests. Sheep inoculated with whole blood from sheep receiving 17th, 30th, and 40th passage tissue culture virus exhibited no visible clinical symptoms but did withstand challenge from known virulent BT virus. Further passages of the tissue culture virus onto tissue culture cells and subsequent testing in sheep will be continued.

Attempts to isolate the virus from whole blood of 13 reacting sheep were successful in 2 cases. Four serial blind passages in tissue culture were made on the blood from the other 11 animals, with negative results.

Serum neutralization tests, using a tissue culture virus or concentrated chicken embryo virus, were conducted on serum from 186 sheep, including 56 animals used in the Culicoides variipennis (flies) transmission studies. Normal serum and serum from sheep exposed to the BT virus but not infected, displayed no specific BT antibodies, whereas the serum from those animals exposed to the BT virus and followed by a resultant infection to bluetongue consistently showed a specific log index of 3.5.

Studies on the transmission of bluetongue in sheep by insect vectors is a cooperative project with the Entomology Research Division, Kerrville, Texas, with emphasis directed toward Culicoides variipennis.

Eighteen flies (colony raised) that fed on a bluetongue infected sheep transmitted the virus 15 days later when they fed on a susceptible sheep. However, 19, 10, and 2 flies which had fed on a BT infected sheep did not transmit the disease when fed 13 days later on susceptible sheep. However, the 2 aforementioned flies, which were immediately processed after feeding on the susceptible sheep, transmitted the virus when injected into a susceptible sheep. The aforementioned 19 flies were immediately processed and subsequently passaged on tissue culture cells with isolation of the BT virus as evidenced by cytopathogenic effect (CPE), serum neutralization tests, and inoculation of sheep.

Sixty-one flies that fed on a BT-infected sheep, and then 10 days later fed on a susceptible sheep, did not transmit the virus. These flies were immediately processed and injected into a susceptible sheep with transmission of the virus.

Twenty-seven flies that fed on a BT-infected sheep and then fed on a susceptible sheep 15 days later, did not transmit the virus. Thirty-seven and 122 flies that fed on a BT-infected sheep transmitted the BT virus to their respective susceptible sheep upon taking their second blood meal 10 days later.

Thirty-eight, 1, 10, 36, and 20 flies that fed on a BT-infected sheep took their second blood meals 13 days later (except for the 38 flies which fed 10 days later) on their respective susceptible sheep with no transmission of the virus.

Six lots of 43 flies each, after feeding on a BT-infected sheep, did not transmit the virus after taking their respective second blood meals 8, 9, 10, 13, 15, and 20 days later on susceptible sheep. Four lots of 1 fly each did not transmit the virus when fed on susceptible sheep 16, 19, 20, and 21 days later, respectively, after taking their first blood meal on a BT-infected sheep.

Six and 2 flies that fed on a BT-infected sheep, took their respective second blood meals on susceptible sheep 16 and 20 days later with negative transmission of the virus. Fifty-three, 107, and 100 flies, after feeding on a BT-infected sheep, failed to transmit the disease 10 days later when they fed on their respective susceptible sheep. One and 47 flies failed to transmit the virus when fed on their respective susceptible sheep 13 days after having fed on a BT-infected sheep. One hundred six flies, which had fed on a BT-infected sheep, did not transmit the virus to a susceptible sheep when fed 7 days later. Three and 6 flies, when fed on the same susceptible sheep 12 and 13 days respectively after having first fed on a BT-infected sheep, did not transmit the virus.

Approximately 2,500 flies which had fed on BT-infected sheep but not exposed to susceptible sheep for a second blood meal, were incubated in varying lots for integrated periods of time ranging from day zero through 14, at which times they were stored at -60 F.

All flies, except those processed at the time for virus isolation, used in the direct BT transmission studies, including those exposed to a susceptible sheep but not taking a blood meal, were stored at -60 F.

Sixty-eight flies which had fed on a BT-infected sheep, were found to be infective to a susceptible sheep after having been incubated for 10 days and then stored in a dead state at room temperature for 10 days.

Seventeen flies, held for 18 days after feeding on a BT-infected sheep, were placed in an airtight vial containing a minimal amount of Mycostatin and then stored for 6 days at room temperature, were not found to be infective to a susceptible sheep.

Five lots of flies incubated 10, 10, 13, 13, and 15 days, respectively, following a blood meal on BT-infected sheep, were stored for over 5 months at -60 F., at which time the flies were processed for attempted viral isolations in tissue culture and sheep. Viral isolation was successful in both sheep and tissue culture in the single instance of 1 lot of flies which had been incubated 10 days prior to storage. Virus isolation in sheep from 1 lot of flies incubated 13 days was successful, whereas the remaining virus isolation attempts were negative.

Four viral isolates, one of which is a suspected field variant, are being typed in sheep and by tissue culture methods. Results are inconclusive, so further testing is in progress. (Denver, Colorado)

The technique of agar diffusion was applied to a study of bluetongue virus antigens prepared from infected mouse brains, chicken embryos and cell culture fluid. Antigens from these different sources, contributing to precipitate formation, were virus-specific, noninfective and serologically indistinguishable one from another in the systems tested. The onset and production of circulating ovine anti-bluetongue virus precipitin was correlated to corresponding data for homotypic virus infectivity neutralizing antibody. The onset of precipitin formation was detected about the same time as for neutralizing antibody, but the precipitin persisted longer. An anamnestic response was observed for neutralizing antibody but not for precipitin. An antigen-antibody system, containing one component in weak concentration, precipitated if adjacent to a positive system but not if placed by itself. This observation, termed the "recruiting effect," can influence quantitation of precipitin. (Pullman, Washington)

Female mice were immunized with bluetongue virus just prior to or during pregnancy. Only lacteal transfer of neutralizing antibody to bluetongue virus was demonstrated from immune mothers to their offspring. However, the existence of in utero transfer at a very low level was not excluded.

The passive immunity of the offspring gradually increased during the first 12 days after birth. A marked protection was noticed also in 24-day old mice indicating that mice older than 2 weeks absorbed antibody. After weaning, the passive immunity was lost at a rate that agreed with the reported half-life for mouse antibody of 2.5 to 3 days.

No detectable passive immunity was obtained by offspring of females fed virus-infected material. The use of this finding as a possible diagnostic tool for strain differentiation was discussed. (Pullman, Washington)

In 1962 the Denver Animal Disease and Parasite Research Laboratory was remodeled and equipped for investigations on bluetongue (BT) virus disease of sheep and other animals.

The progress in cell cultures includes the colonization and testing of various ovine and bovine organ cell lines. This research is preliminary to the development of a satisfactory virus-serum neutralization test. It will also furnish an adequate biological medium for basic viral investigations utilizing fluorescent antibody techniques. Homogeneous cell cultures colonized from susceptible body organs will furnish the virus laboratory with a more nearly defined living experimental system. Plaque assay, cytopathogenic studies, serological tests, and virus titrations depend on homogeneous cell lines that will give reproducible results.

The virus has been adapted to embryonating chicken eggs and further studies are being conducted to determine highest titers and maximal yield of viable material from homogeneous egg embryos.

The study of the pathogenesis of bluetongue disease of sheep indicates that: 1. The intradermal route of inoculation is the most effective method of producing bluetongue infection in sheep. 2. The oral route of administration

will not cause a susceptible animal to develop the disease, but may cause sensitization and cause more severe signs and symptoms of disease when later challenged via the intradermal route. 3. Sheep keds (Melophagus ovinus) are capable of transmitting bluetongue disease to sheep. Sheep ked transmission of bluetongue diagnosed by typical signs and symptoms occurred in 16 out of 28 sheep in the insect vector transmission experiments.

The study of field isolates still indicates that there is only one strain of bluetongue virus in the United States. One isolate from California, BT 216, still may be proved to have some slight variation in its antigenicity when compared to California BT 8 which is presently incorporated in the commercial vaccine.

A study of field isolates from cattle indicates that at least three negative subpassages in sheep must be obtained before a negative result should be reported.

The Animal Disease and Parasite and the Entomology Divisions of the Agricultural Research Service have instigated a full time cooperative research project at the Denver ADP Laboratory to further study the problem of the possible transmission of virus diseases to domestic animals by various insects.

B. Scrapie

Scrapie, a generally fatal disease of sheep, was first diagnosed in this country several years ago, but is not considered to be firmly established. An eradication program is in progress.

It is apparent that the two chief factors involved in the disease are a transmissible agent that has not been characterized in detail, and genetic constitution which probably determines susceptibility. Additional information about the disease is needed to improve eradication procedures. Study of the disease has been continued by an ADP animal pathologist in cooperation with the Agricultural Research Council Field Station at Compton, England. In this study of scrapie in experimentally infected goats, it has been determined that the microscopic lesions of the disease are manifest only in the nervous system. In contrast with sheep, all goats have been susceptible regardless of method of inoculation. The disease is characterized by degeneration of nerve cells, especially in the thalamus of the brain. The research under way at two locations in Great Britain is aimed toward characterization of the transmissible agent and clarification of the apparent genetic influence on susceptibility. In Scotland, evidence has been accumulated to show that scrapie can be transmitted to goats by contact with either infected sheep or goats. Confirmation was based upon clinical signs of the disease and laboratory procedures. Four goat kids developed scrapie within 12 months subsequent to intracerebral injection of goat brain material.

An ether-extracted scrapie sheep brain preparation, passed through calcium phosphate and injected into sheep, is believed to be the most "pure" preparation of scrapie material yet shown to be active. This finding makes the work of searching for the causative agent(s) of scrapie more hopeful.

In England a good biochemical approach is being made to isolate the causative agent of scrapie from sheep, goat, and mouse tissue. The injection of goat brain material into several mice induced within 7 to 14 months the onset of signs resembling those of scrapie. The condition has been transmitted from mouse to mouse by inoculation. The infection rate in mice was 100 percent. There is evidence of the adaptation of the agent in mice. These studies could ultimately establish the mouse as an important and economical tool in scrapie research. The recent contact exposure studies with goats strengthen the theory of the contagious nature of the disease under certain conditions.

C. Vibriosis

In 1961, in work in cooperation with the Colorado Agricultural Experiment Station, 250 ewes, grouped at random into 10 isolated lots of 25 animals each, were used to determine: a) minimum concentration of killed vibrio fetus cells to immunize against vibriosis; b) efficacy of mineral oil and alum adjuvant V. fetus vaccines in eliciting a high and lasting immunity. A single adjuvant vaccine contained 0.5 mg., 1.0 mg., or 2.0 mg. V. fetus cells per ml., and was administered in one 5 ml. subcutaneous injection to ewes of a single lot, prior to breeding. Challenge to immunity during advanced gestation was by oral inoculation with virulent V. fetus culture.

No abortions occurred in 63 ewes vaccinated with mineral oil adjuvant vaccine. Three of 69 (4%) ewes aborted after receiving alum adjuvant vaccine. An additional 70 ewes, vaccinated with concentrated cells without adjuvant, resulted in 10 abortions (14%), compared to 22 abortions (88%) occurring in 25 non-vaccinated, orally challenged control ewes.

In 1962 immunization studies on vibrionic abortion in sheep were conducted to determine the protection afforded sheep vaccinated with vibrio fetus serotype I killed vaccine, when challenged with V. fetus serotype V live culture, and vice versa. Primigravid ewes were selected at random to form lots, isolated from each other. Ewes of designated lots, prior to breeding, were vaccinated with a single dose of one V. fetus serotype bacterin. Challenge to immunity during advanced gestation was via the oral route with a measured dosage of the heterologous V. fetus serotype culture.

Ewes vaccinated with one V. fetus serotype bacterin were not protected against vibrionic abortion when their immunity was challenged with the heterologous V. fetus serotype culture.

Current studies, and previous investigations reported by this station, indicate that ewes vaccinated with V. fetus serotype I, or V. fetus serotype V bacterin were immune when their immunity was challenged with a measured dosage of the homologous V. fetus serotype culture. These findings indicate strain specificity immunization against vibrionic abortion caused by one V. fetus serotype.

In 1961, in cooperation with the Montana Agricultural Experiment Station, studies on the reservoir of infection, fecal and vaginal cultures made from 45 ewes 7 months after exposure to V. fetus by either artificial or natural means, failed to reveal evidence of infection. The flock lambed normally the following spring.

A study was made of the pathogenicity of V. fetus which failed to show that vibrios isolated from the ovine gall bladder have marked pathogenicity for the pregnant ewe. However, under the conditions of challenge employed, there was no appreciable difference between vibrios isolated from the gall bladder and a strain of V. fetus isolated from an aborted fetus. Information concerning the loss of pathogenicity by V. fetus cultures would be of value. It is difficult to compare pathogenicity of strains when many of the factors involved are not understood.

Vibrios resembling V. fetus in morphology were isolated from the feces of ewes associated with a vibriosis outbreak and from the feces of virgin ewes without history of contact with V. fetus. V. fetus has not been isolated from the feces of naturally infected ewes at the laboratory of the Montana Agricultural Experiment Station, but was recovered from the feces of artificially inoculated ewes 24 hours after inoculation. Subsequent cultures were negative.

In the evaluation of commercially prepared V. fetus vaccine, the Montana laboratory participated in the 1960-61 field trial of V. fetus bacterin prepared by a commercial laboratory. Seven flocks of sheep, totaling 16,520 breeding ewes, were selected for the trial. The number of ewes actually involved in the controlled experiment was 6,223, of which 3,513 were yearlings and 2,730 were older ewes. The total number of vaccinated ewes was 3,067, and the number of control was 3,156. Lambs were obtained and autopsied from all of the ranches experiencing losses. Vibriosis was not diagnosed on any of the ranches, but ovine virus abortion was diagnosed on 4 ranches. The sporadic nature of ovine vibriosis was again affirmed. It would also appear that the incidence of ovine virus abortion in Montana is somewhat greater than previously thought.

In 1962, at the Montana laboratory, seven isolants from ovine bile were tested for pathogenicity in pregnant ewes by rumen injection in late pregnancy. Six of the isolants produced abortions as did a fetal strain of V. fetus. This finding, in conjunction with the results obtained from previous serologic and physiologic studies leads to the conclusion that many Vibrio cultures isolated from naturally infected gallbladders are actually V. fetus.

Vibrio resembling V. fetus were isolated from two of twelve ovine gallbladders cultured from a ranch which had an abortion outbreak due to V. fetus of rare serotype three years previously. Antigens made from the bile isolants were not agglutinated by antiserums of common serotypes. Serologic comparison between the fetal and bile isolants has not yet been made.

Routine semen cultures which were made from 15 supposedly normal rams resulted in the isolation of V. bubulus from 5 rams and of the ram epididymitis organism from one. This is the first evidence that Montana sheep are infected with the ram epididymitis organism.

Forty-six Vibrio isolants of diverse origin were tested for growth in a medium containing 1 percent glycine. The only group which consistently failed to grow in the presence of glycine was composed of V. fetus cultures of bovine origin. The test is apparently of value in distinguishing between isolants of bovine and ovine origin. Isolants from ovine bile which do not show fair to good growth in the presence of glycine, may not be V. fetus.

Colony studies conducted on Vibrio isolated from ovine bile revealed that many such isolants have colonies which appear to be identical with those observed in ovine fetal strains of V. fetus.

An outbreak of vibriosis, due to serotype I, took place on the Paugh ranch in the spring of 1962. In the fall of 1960,174 Fulton ewes on this ranch were vaccinated with Baldwin V. fetus vaccine (serotype I). There was no evidence of vibriosis in either the vaccinated ewes or the controls in the spring of 1961. In the spring of 1962, 35 Fulton ewes aborted. Ten of these ewes had been vaccinated in the fall of 1960. It would appear that protection the second year following vaccination is not very good; a single additional vaccination in the fall of 1961 might have conferred adequate immunity. Abortions occurred in 7 breeding lots although the rams were of diverse origin. It is extremely unlikely that the rams were the source of the outbreak.

Lambs were obtained for culture from one other ranch (Windsor Livestock) which was on the vaccine experiment in 1960-61, but all cultures were negative for V. fetus. Lambs were not obtained from the other five ranches which had been on the experiment and there was no reason to believe that they had any disease problem.

A study was made in cooperation with Utah to determine the role of the ewe as a reservoir of infection for V. fetus. Cultures of 197 placentas from 2 bands of sheep which had 15% abortions the previous year, failed to reveal any Vibrio fetus. Also culture of aborted lambs was negative for Vibrio fetus. Twenty-two of 39 aborted lambs were cultured. Cultures of the bile of 18 ewes, whose placentas were infected with V. fetus the previous year, were found negative for V. fetus. In a field experiment involving 4,055 ewes, both yearlings and old ewes, there were about 2 to 2½ percent abortions in both the vaccinated and non-vaccinated ewes.

One of two herds vaccinated with Vib-Vac had a serious outbreak of vibriosis (rate of abortion 14.3%). Vibrio organisms were isolated from a ewe vaccinated the previous year. No vibrio organisms were isolated from the other herd which had an abortion rate of 1.7%.

About one third of the sheep tested from four different herds excreted an agent of the psittacosis-lymphogranuloma group but no vibrio organisms in the feces. This agent caused abortion in pregnant ewes identical to the picture of enzootic abortion.

Characteristic lesions in virus infected lambs and placentas were found which are distinctly different from lesions described in vibrio infected lambs and placentas.

Physiologic studies indicated that a given vibrio organism may have progeny with different physiologic properties when passed in ewes. Physiologically different strains were isolated from aborted lambs of the same herd.

D. Viral Ulcerative Dermatosis

In 1961, in cooperation with the Colorado Agricultural Experiment Station, success was achieved in isolating and culturing a viral agent from tissue exudates collected from a naturally occurring case of ovine ulcerative dermatosis (U.D.). After 10 serial passages on tissue culture, the culture fluids produced lesions typical of field cases of ulcerative dermatosis. The virus of contagious ecthyma (C.E.) was also cultivated on bovine kidney cell monolayers. The 2 viruses, when inoculated into scarified skin of lambs, produced lesions which could not be differentiated grossly or microscopically. The several physical properties of the two agents which were studied were found to be similar and did not produce a criteria for differentiation of the two diseases. The only distinguishing feature observed for the two diseases is that lambs which have become refractory following repeated inoculation with one agent were found to be susceptible to the other agent.

The experimental work completed in 1960-61 indicates that both ulcerative dermatosis and contagious ecthyma are caused by viral agents which can be propagated on bovine kidney cell cultures. No difference in the properties of the two viral agents were detected by the methods employed. Immunologic studies suggest that the etiological agents are poor antigens, or that the methods employed were not suitable for detecting antibodies. The studies further indicate the two viruses are closely related but not antigenically identical.

In 1962, the investigation of ulcerative dermatosis continued with 1) studies on the cultivation of UD virus on tissue cultures, immunology, and properties of the virus being repeated, using a new source of infectious material to see if the results could be duplicated; 2) attempts made to reproduce lesions on the external genitalia of young rams, using exudate from field cases of the disease.

Outbreaks of UD are being sought through the Wool Growers Association, county agents, and practicing veterinarians in Colorado and southern Wyoming, as a source of new material for further investigations.

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# PARASITES AND PARASITIC DISEASES OF SHEEP AND GOATS
Animal Disease and Parasite Research Division, ARS

Problem. The cost of parasitic diseases to the sheep and goat industry of the United States is estimated to be in excess of $45 million, annually. Disorders caused by parasites are ubiquitous, generally insidious and often overlooked entirely. Diagnosis is difficult, and successful treatments for many of these diseases are not available. Moreover, management practices to avoid spread of parasitisms and to control them are often ineffectual. The problem is to develop, through a planned, balanced program of basic and applied research, knowledge for preventing, controlling or eradicating parasitic diseases so as to provide for healthy animals, insure adequate supplies of high quality lamb for an expanding population, avoid or minimize economic losses caused by these diseases, and thereby contribute to a prosperous agriculture, a sound national economy, a high standard of living, and a healthy population.

## USDA PROGRAM

The Department has a continuous long-term program involving biochemists, parasitologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of parasites and parasitic diseases of sheep and goats. Research is being conducted on these diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 8.3 professional man-years. This effort is divided among sub-headings as follows:

Lungworms 1.0 at the Beltsville Parasitological Laboratory.

Bionomics of Coccidial Parasites 2.0 at the Beltsville Parasitological Laboratory.

Effects of Helminth Infections on Serum Proteins 0.5 at the Beltsville Parasitological Laboratory.

Gastrointestinal Nematodes 2.1 at the Beltsville Parasitological Laboratory, and under a cooperative agreement with the Kentucky Agricultural Experiment Station at Lexington.

Helminth and Protozoan Parasitism in the South 1.5 at the Regional Animal Disease Research Laboratory, Auburn, Alabama, and through informal cooperation with the Mississippi Agricultural Experiment Station, State College.

Biology, Pathogenesis, and Control of Helminth Parasites of Sheep in the Southwest 1.0 at the University Park, New Mexico, field station, and through informal cooperation with the New Mexico Agricultural Experiment Station, at University Park.

Biology of the Liver Fluke 0.1 under cooperative agreement with the Montana Agricultural Experiment Station, Bozeman.

Effect of Intestinal Roundworms on Metabolism 0.1 under cooperative agreement with the North Dakota Agricultural Experiment Station, Fargo.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 5.6 professional man-years devoted to this research. Studies are aimed at locating areas of parasitism with the lungworm and developing information on the habits of the parasite which will be useful in its control. Research is directed toward means for controlling coccidial parasites. Four western States have cooperative studies through regional research project W-35, Nematode Parasites of Ruminants to clarify some of the major problems caused by gastrointestinal nematodes. Management procedures are being developed based on critical observations of parasite incidence under different systems of flock management. Genetic resistance is being evaluated with the possibility that some breeds, or lines within breeds, may be more resistant to certain parasites. Improved methods are being developed for diagnosing infections with specific parasite species. Parasitologists are seeking to identify snails which serve as intermediate hosts of liver flukes and are determining factors concerning the ecology of these snails which may provide a means for breaking the life cycle of the fluke. Enzootic areas of fluke infestation are being located and methods of elimination evaluated. Studies at Nevada are aimed at measuring precisely the damage caused by flukes and how this damage is produced in order that scientifically sound countermeasures can be evolved. Prevention through immunization is under study. Existing control measures are being applied to determine their effectiveness under conditions found within the State.

Industry and other organizations are engaged in the formulation of compounds and explorations for chemicals that may be used safely as parasiticides. Generally, these companies have their own facilities, including laboratories, barns, and other structures containing pens for experimental animals, and in some cases pastures. The work of these companies and the results, expenditures and related matters are ordinarily confidential, since they involve eventually saleable products. Estimated annual expenditures are equivalent to approximately 20 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Lungworms.

In 1961, at the Beltsville Parasitological Laboratory, Beltsville, Maryland, an experiment to determine the earliest age at which larvae of the thread lungworm, Dictyocaulus filaria, can infect sheep demonstrated that larvae only 100 hours after passage from infected sheep may produce fatal infections when administered to lambs.

In 1962, at this Laboratory, lambs and kids that had recovered from thread lungworm infections were still strongly immune to reinfection up to 15-1/2 months after recovery, even when challenged with as many as 60,000 larvae. Comparable susceptible animals developed severe infections when given the same larval dosages. Serum protein changes and eosinophilia in the immune animals indicated that the challenge exposures had stimulated the immune responses of the host even when no other evidence of exposure was noted. Growth and sexual development of worms were definitely inhibited in immune animals and the immune reactions appeared to be active against all stages of migration and development. Resistance against lungworm infection developed in the lungs of kids in which the mesenteric lymph nodes were by-passed by infecting fourth-stage larvae into the jugular vein. The presence of circulating antibodies was indicated by the deactivation of fourth-stage larvae by immune serum and the appearance of a diffuse precipitate in the vicinity of the worm.

A moderate immunity to sheep lungworm was apparently produced by two exposures of lambs to infective larvae of the cattle lungworm. Reduced larval production, reduced worm burdens, inhibited worm development, and reduced lung pathology were found in "immunized" animals.

B. Bionomics of Coccidial Parasites.

In 1961, investigations at the Beltsville Parasitological Laboratory showed that suckling lambs may be as ready prey to coccidiosis as weaned lambs. The studies involved 10-week-old suckling lambs that were experimentally fed moderate to large numbers of oocysts of two or three species of coccidia from sheep. This study indicates that, contrary to a rather widespread belief, late weaning of lambs may be of little benefit from the standpoint of susceptibility to coccidiosis, all things being equal.

Studies indicated that at least some species of coccidia parasitic in sheep, although able to infect goats, complete only a portion of the life cycle in these latter animals, which are but little affected by the infection. These studies indicated that within a species, there are physiologic strains, some of which are adapted to sheep and others to goats. In this study, stages of coccidia normally occurring in the intestinal epithelium, and not known to occur elsewhere in the body of hosts, were found for the first time in the mesenteric lymph nodes of a sheep and a goat.

Oocysts of coccidia swallowed by rodents may respond to conditions therein by partial, but not complete, excystation. It was not determined whether such oocysts are infective to sheep and may, therefore, be disseminated by rodents, but in light of similar observations previously made on eggs of certain nematodes, the possibility is considered strong.

That a relationship can exist between an imperfect condition of wool and experimental coccidiosis was confirmed this year. About one month after infection, when coccidiosis had run its course, breaking of wool and loss thereof occurred over significantly large areas of the bodies of the affected animals.

Oocysts of ovine coccidia that had been stored in water for 5 years, were determined to be viable through the application of an in vitro test.

Studies on excystation of coccidial oocysts in their hosts, and in vitro, the latter conducted by the enzyme-bile technique mentioned last year, presented evidence that the mechanism of excystation, and infection, of sheep coccidia and avian coccidia, are essentially similar. In these studies evidence was obtained that excystment of the parasites follows a change in the physiology of the parasites from that of the quiescent stage outside the host, to one of activity for parasitism in the host; in sheep coccidia and in a turkey coccidium, the activity of excystment was renewed almost immediately when the parasites were warmed on the warm stage of the microscope after they had been interrupted in the excystment process by placing them for over a week in the refrigerator.

The studies revealed, moreover, that sheep coccidia need an incubation period of about 5 hours to start the physical excystment process in vitro and that the following conditions will serve the purpose - (1) incubate for 5 hours in pure bile; (2) incubate for 5 hours in saliva or steapsin solution, then add bile; and (3) incubate for 3 hours in distilled water, then for 2 hours in the enzyme solution, and then place in bile.

In 1962, at the Beltsville Parasitological Laboratory, it was found that enzymes of plant origin influence hatching (excystation) of oocysts of sheep coccidia. The enzymes found by in vitro tests to promote excystation, include alpha and beta amylase, Takamine pectinase and cellulase, and an amylase and a protease derived from fungi. Although not known to be the case, it is possible that active enzymes of plant origin may occur in the digestive tract of sheep and thereby influence infection of these animals with coccidia.

Hatching (excystation) of oocysts of coccidial parasites of sheep occurs only after a period of physiological development of the invasive bodies (sporozoites) contained therein. This development, permanent in nature and capable of being interrupted and then resumed, can be initiated by exposure of the ripened (fully developed) oocysts to subcutaneous fluids of the host (5 hours) or to digestive enzymes of the host for about 17 hours.

C. Effects of Helminth Infections on Serum Proteins.

In 1961, at the Beltsville Parasitological Laboratory, a study was conducted in cooperation with the Animal Husbandry Research Division on the changes in the blood serum proteins of 4 groups of 5 cross-bred ram lambs each, which were subjected, respectively, to minimal, moderate, and heavy exposures to parasitic infection. These lambs were part of the same experimental bands discussed in the report on gastrointestinal nematodes. Serum protein studies verified the parasitological data acquired in the aforementioned experiment that severe helminthic infection was prevented from occurring in these lambs by a combination of good management practices and timely use of proper medication. Albumin to globulin (A/G) ratios and serum globulin percentages

fluctuated but did not depart markedly from the normal range in any of the 4 management bands. Gamma globulin percentages did not change markedly in any of the groups, and were relatively comparable. However, the beta globulin percentage varied more noticeably than the gamma globulin percentage, but were relatively minor and within the normal range. Another indication that parasitism did not attain gross proportions in these animals was the absence of significant quantitative changes in the total serum proteins (TSP). In all 4 bands the average TSP was higher at the end of the study than at its inception. The results of this study extend and confirm the conclusions derived from prior studies in this series in that the degree of change in serum proteins of lambs apparently depends to some extent on the type and severity of parasitism and possibly on the breed of the host animal.

In 1962, at this Laboratory, no work was done on this project because of reductions in personnel and in numbers of experimental animals. The project leader went to Australia on a Fulbright Grant to study sheep parasites for one year. The reduction in numbers of experimental animals was occasioned by having to dispose of the entire sheep flock prior to moving to the area formerly occupied by the Animal Disease Station at the Agricultural Research Center, Beltsville, Maryland.

D. Gastrointestinal Nematodes.

In 1961, at the Beltsville Parasitological Laboratory, in cooperation with the Animal Husbandry Research Division, and the Antiparasitic Investigations Research Group of this Division, a second-year study was conducted to determine the effect of various types of management, including anthelmintic treatments, on parasitism in lambs. Four bands of 75 lambs each were studied. Band 1 was quartered on a dry lot only and fed pellets and alfalfa hay: Band 2 was moved to clean pastures periodically: Bands 3 and 4 were moved bi-weekly to previously grazed, or contaminated pastures. All lambs were on continuous phenothiazine-salt prophylaxis. Bands 2 and 3 also received therapeutic medication with N.F. phenothiazine, while Band 4 received the purified form of the drug, after the appearance of clinical parasitism. Conclusions resulting from the previous year's study, such as the earlier institution of anthelmintic treatments and/or using a purified form of phenothiazine, were implemented successfully in producing greater weight gains and reducing anemia and fatalities, particularly from haemonchosis, in the lambs under surveillance. Data obtained from the periodic examination of the feces for parasite eggs of 20 representative ram lambs of each band, and from necropsy of 40 lambs during the course of the study, indicated that (1) the lambs on dry lot remained essentially parasite-free, and made excellent weight gains; (2) the lambs on clean pastures gradually developed clinical parasitism during the summer, but neither the weight gains nor the hematocrits were appreciably affected; (3) Band 3 lambs on contaminated pastures and treated with N.F. phenothiazine developed haemonchosis and showed anemia and reduced weight gains early in July, and (4) Band 4 lambs, also on contaminated pastures but treated with purified phenothiazine maintained higher blood levels and greater weight gains than the lambs of Band 3. Worm counts at necropsy showed lambs of Band 4 had fewer worms, especially Haemonchus contortus, than

Band 3. These counts revealed that marked Haemonchus infections occurred in Band 3 in June, August, and September, decreasing somewhat after each therapeutic treatment with N.F. phenothiazine, whereas, treatments with purified phenothiazine kept Haemonchus under continuous control in Band 4. Although lambs of Bands 2, 3, and 4 harbored moderate numbers of Strongyloides papillosus, strongyloidiasis was not an important factor as in the previous year. Other than the two species of worms already mentioned, small numbers of Cooperia, Trichostrongylus, Nematodirus, Trichuris, and Oesophagostomum were recovered. Deaths from parasitism occurred only in Band 4, and then amounted to less than 3 percent. The mortality figures were much lower than those of the preceding year, demonstrating the effectiveness of proper management and the judicious use of medication.

In 1962, at the Beltsville Parasitological Laboratory, the work was continued for a third-year study on the effects of pasture management and chemotherapy in relation to parasitism, and confirmed the results of previous years. Band 1 lambs raised on dry lot and fed green chop remained essentially parasite-free and showed no effects of parasitism. Band 2 lambs raised on clean pastures gradually developed clinical parasitism but none was severely affected. Band 3 lambs, on contaminated pastures, developed clinical parasitism relatively early in the grazing season which was not adequately controlled by 2 treatments with N.F. phenothiazine, but which was reduced to a lower level by 2 subsequent treatments with purified phenothiazine. Band 4 lambs on contaminated pastures, developed clinical parasitism and received 3 treatments with purified phenothiazine. These treatments reduced the effects of parasitism but were not as effective as the 4 treatments in Band 3. Individual animals in both bands 3 and 4 became seriously anemic but only one death resulted from haemonchosis; this death occurred in Band 3. Parasites other than Haemonchus contortus were present in insignificant numbers and apparently had little clinical effect. Overall, excellent control of clinical parasitism was achieved by the management and therapeutic techniques employed.

In 1961, at Lexington, Kentucky, under a cooperative agreement with the Agricultural Experiment Station, and in informal cooperation with Southern Regional Research Project S-21, "Gastrointestinal Parasites of Ruminants," it was found that the second year's observations on pure infections of Haemonchus contortus under pasture conditions indicated that the free-choice consumption of phenothiazine-salt (1:9) was more effective against control strain A than the resistant strain B. The natural transmission of H. contortus to the lambs in the untreated groups on these pastures started between the middle of May and the first of June in 1960. The epidemiology also showed a winter carry-over of immature stages or agamous adults in ewes.

In a field test during the 1960 grazing season a series of Ruelene drenches at 3-week intervals were more effective than the same number of phenothiazine drenches in controlling the gastro-intestinal parasites of lambs on pasture. Although one of 10 lambs treated with Ruelene died during the course of the study, the Ruelene-treated lambs average daily gain was slightly better than the phenothiazine-treated lambs. A similar group of lambs kept under dry-lot conditions and treated with 4 Ruelene drenches at 3-week intervals, showed poor weight gains and 2 of 5 animals died.

A series of tests with a purified phenothiazine against experimental infections of resistant strain B H. contortus in lambs resulted in a higher (but not statistically significant) average removal efficacy than 2 N.F. Green phenothiazines.

In 2 field tests, single oral doses of MK-360, Ruelene, and phenothiazine ranked in this order in efficacy in reducing post-treatment egg counts in feces.

Rendering rats, which are naturally refractive to T. axei, visibly vitamin A deficient, did not make them susceptible to this worm.

Continued efforts to cultivate T. axei in vitro were unsuccessful.

In 1962, at the Kentucky Agricultural Experiment Station, and in informal cooperation with Regional Project S-21, it was found that in the third year's observations on pure infections of Haemonchus contortus under pasture conditions the free choice consumption of phenothiazine-salt (1:9) continued to be much more effective against control strain A than the phenothiazine-resistant strain B.

Laboratory tests on experimental infections of strain B H. contortus comparing removal efficacies of single doses at .1 gm/lb. of two N.F. green on one purified phenothiazine product resulted in no significant difference of activity. Likewise, laboratory tests on experimental infections of strain B H. contortus comparing suppression of egg production and inhibition of larval development of small (.1 gm and .25 gm) daily doses of regular N.F. green, microfine, and microfine-purified phenothiazine products resulted in no significant differences among the six preparations tested.

In a controlled test of anthelmintic activity in lambs thiabendazole at 50 mg/kg was more completely effective against a greater number of species than the organic phosphate Famophos (Cl 38,023) at 100 mg/kg. The latter was characterized by activity shortcomings against Strongyloides, Nematodirus and Oesophagostomum and immature worms. Neither compound was active on Trichuris.

Field tests on the anthelmintic activity of organic phosphates following pour-on administration in cattle revealed activity of SD3562, Famophos, and Ruelene in reducing post-treatment EPG, whereas Neguvon and Tiguvon were devoid of action.

Rats visibly vitamin A-deficient, were not susceptible to Trichostrongylus axei.

Mongolian gerbils were successfully infected with the animal pathogen T. axei. The technical and economic advantages of this laboratory host-parasite combination are numerous.

E. Helminth and Protozoan Parasitism in the South.

In 1961, at the Regional Animal Disease Research Laboratory at Auburn, Alabama, experimental lambs showed some resistance to reinfections with coccidia when given repeated doses of sporulated oocysts mixed in their feed. This resistance was more apparent in the 3rd and 4th inoculations and was demonstrated for Eimeria faurei, E. crandallis, E. arloingi, and E. ninakohlyakimovae. The resistance to reinfection appears to be species specific. Only one species of coccidia, E. ahsata, produced a strong immunity to reinfection after a moderate to heavy infection.

A preliminary investigation on the life cycle of Eimeria ahsata, a coccidian parasite that was recently found to be very pathogenic to lambs, revealed (a) at 2 days after inoculation sporozoites were found in epithelial cells of the lower small intestine; (b) young schizonts were located in the duodenum and jejunum on the 4th and 7th day; (c) at 14 days schizonts were found throughout the small intestine with as many as 4 in the lacteals of one villus. They ranged up to 220u in size and some had very thick coats; (d) macroscopic schizonts were still present at 17 days, at which time gametocytes and developing oocysts were noted in the cecum and colon.

In 1962 at the Regional Laboratory, mild clinical signs were noted for the first time accompanying a heavy infection of Eimeria crandallis in a 2-month-old lamb. The oocysts of Eimeria crandallis were found in the epithelial cells covering the ends of villi of a lamb, causing the villi to have a distinctive, tiny circle which could be of value in diagnostic examinations. Large numbers of oocysts are not necessary to infect or reinfect lambs with Eimeria arloingi. Lambs receiving approximately 400 sporulated oocysts per day of this species for 20 days showed heavier infections than those receiving 800 per day for 10 days and another receiving a single dose of 8000 oocysts.

Additional information was obtained on the endogenous stages of the life cycle of Eimeria ahsata, a highly pathogenic coccidian in lambs. Sporozoites were found in the upper small intestine. Immature schizonts were in the lower part of the small intestine. Young schizonts were covered with a very thick wall of host material that was fibrous, with the cilia-like strands radiating outward. Microgametocytes, macrogametocytes, and schizonts were located, measured, and photographed. The largest schizont, at 15 days, measured 162.5u by 265u. As few as 16,000 oocysts of Eimeria ahsata caused massive infections of a young lamb, with very few indications of clinical coccidiosis. When 31,000 oocysts were given to two others, the infections caused clinical coccidiosis in both and the death of one lamb. Many oocysts expelled during the last three to eight days of these massive infections proved to be malformed, delicate "duds" that distorted easily during manipulations.

In 1961, through informal cooperation with the Mississippi Agricultural Experiment Station and the Southern Regional Animal Disease Research Laboratory, a study comparing the degree of parasitism in early and late lambs during 1960 showed the same general trend as in previous years, namely, that at any given age, late (February-born) lambs harbor more parasites than early (November-born) lambs of the same age.

In 1962 these same research laboratories reported previous work showed that late lambs of a given age would harbor more worms than early lambs of the same age. This year, lambs grazing pastures together had comparable numbers of worms regardless of age, at least after 120 days of age, indicating that time of year for grazing is more important than age of the host in the acquisition of parasites by sheep.

The research at Auburn, Alabama, and State College, Mississippi, on Helminth and Protozoan Parasitism in the South, was coordinated with Southern Regional Project, S-21 on "Gastrointestinal Parasites of Ruminants."

F. Biology, Pathogenesis, and Control of Helminth Parasites.

In 1961, at the University Park, New Mexico, Field Station, with informal cooperation with the New Mexico Agricultural Experiment Station, and in informal cooperation and coordination with the Western Regional Project W-35, Nematode Parasites of Ruminants, the following research was reported on the life histories, biology, and pathogenesis and control of certain helminth parasites of sheep in the Southwest:

Immunization of Sheep against Haemonchosis: In a controlled test with 18 worm-free lambs of similar age, breeding, and sex, it was demonstrated that a strain of Haemonchus from pronghorn antelope was significantly less pathogenic than was a strain which originated in domestic sheep. Criteria used to evaluate pathogenicity were weight gains, feed consumption, hemoglobin levels, packed cell volumes, and worm egg counts. Utilizing these same criteria and 12 of the 18 lambs used previously, it was further demonstrated that inoculation with the relatively non-pathogenic antelope strain gave the lambs a significant degree of protection against haemonchosis caused by the sheep strain.

Life History of the Fringed Tapeworm of Sheep: These studies were expanded and intensified by collecting, identifying, and culturing psocid material from new sheep range locations in the Southwest, by experimenting with new diets and substrate modifications in an effort to improve the survival time of the insects in culture, and by modifying the diet of test lambs to make them more susceptible to experimental infection. Attempts made to date to infect lambs experimentally have been unsuccessful.

Failure of Moniezia to Develop in Psocids: Five cultures of various species of psocids were established and the contained insects were exposed to the eggs of Moniezia. The subsequent dissection of 41 psocids from these cultures failed to reveal any developmental stages of cestodes. There was no evidence, therefore, that these insects play any part in the transmission of Moniezia to sheep.

Investigations of the Life Histories of Elaeophora schneideri, Nematodirus lanceolatus, and Nematodirella longispiculata: Due to lack of personnel, accomplishments on these life histories were limited largely to determining suitable techniques. Also, several attempts to infect lambs with the last-

named parasite by using pronghorn antelope as a source of material were unsuccessful. This failure may be attributed to a difference in strains of this parasite. New Mexico sheep do not harbor N. longispiculata but the incidence is quite high in sheep in Wyoming.

On the Occurrence of Liver Fluke in Arizona Sheep: Five of 49 sheep from 9 different farms or ranches in eastern Arizona were found to be infected with the common liver fluke. The 5 infected sheep were from 2 farms which used small snail-infested ponds as the sole source of drinking water for the sheep.

Anthelmintic Trials against the Fringed Tapeworm: Work continued from last year on the evaluation of bithionol pointed up the high efficacy of this compound. The optimum dose rate was determined to be 220 mg/kg. Twenty-four infected sheep were treated at this rate and at necropsy only 4 harbored tapeworms; at the same time, 19 of 21 controls were infected. Trials with the compounds, Freon 112, Freon 113, and hexachlorophene, showed that they were ineffective against Thysanosoma.

Effect of Freon 112 in Removing Common Liver Flukes from Sheep: This compound was given to 3 fluke-infected sheep at the rate of about 600 mg/kg. At necropsy, only one of these animals harbored flukes, the number being 2. Two untreated sheep examined at this time both harbored flukes, the number being 2 in one case and 23 in the other.

In 1962, at the University Park Field Station, with informal cooperation with the Experiment Station and Regional projects, the following research was reported:

Immunization of Lambs with a Relatively Non-pathogenic Strain of Haemonchus from Pronghorn Antelope: Experiments carried out under laboratory conditions for the second successive year indicated that it may be possible to immunize lambs against sheep strain haemonchosis by inoculating them with a relatively non-pathogenic strain of Haemonchus from pronghorn antelope. Intensity of infection following immunizing inoculations as reflected by the degree of anemia was significantly less in antelope strain lambs than in sheep strain lambs. The responses of the lambs in the two groups to challenge with the sheep strain 63 to 64 days after the initial inoculations did not differ significantly, thus indicating that the antelope strain lambs were practically as resistant to challenge as the lambs which received the homologous strain.

Field Trials on the Immunization of Lambs Against Haemonchus: Field trials were conducted to determine the value of a relatively non-pathogenic strain of Haemonchus for immunizing lambs against Haemonchosis. Lambs receiving immunizing inoculations had consistently higher worm egg production and lower hemoglobin levels than uninoculated controls.

Life History of Thysanosoma: Studies on insects of the order Corrodentia continue to show promise in solving the life history of Thysanosoma but to date no lambs have been infected experimentally with cysticorcoids dissected from these insects.

Effect of Bayer 2353 in Removing Thysanosoma from Sheep: Bayer 2353 at a dose rate of 400 mg/kg failed to remove significant numbers of Thysanosoma from 9 aged ewes and 5 lambs as compared with 8 aged ewes and 5 lambs which served as untreated controls.

Effect of Bayer ME-3625 in Removing Thysanosoma from Aged Ewes: Bayer ME-3625, at a dose rate of 4.4 to 5.6 mg/kg, failed to have a consistent and marked effect in removing fringed tapeworm from 4 aged ewes as compared with 3 untreated controls.

The Occurrence of Liver Flukes in Sheep in New Mexico: The incidence of common liver flukes in 3 farm flocks in New Mexico was found to be 53 percent in 38 ewes examined.

Probable Intermediate Snail Host of Liver Flukes in New Mexico: Circumstantial evidence indicates that the snail Fossoria Modicella is a vector of liver flukes in New Mexico.

Effect of Freon 112 in Removing Common Liver Flukes from Sheep: A controlled test involving 12 aged sheep harboring liver flukes was carried out to ascertain the anthelmintic efficacy of Freon 112 when given at a dose rate of 600 mg/kg. The results confirmed previous observations that the compound is highly effective in removing adult flukes. No immature flukes were present in the host animals.

G. Biology of the Liver Fluke.

In 1961, under cooperative agreement with the Montana Agricultural Experiment Station at Bozeman, a study was conducted on the taxonomy of possible small snail hosts of Fasciola hepatica in Montana. Six species in three families, and four genera were tentatively identified. Several species of another family were collected but were not placed in species, as they probably do not serve as intermediate hosts of Fasciola hepatica. Snails were also collected from 15 locations in Montana, identified as to genera, crushed and examined in the laboratory to determine the trematodes that were present in them. Trematodes were found in those from 4 locations. Numerous methods were tried for the culturing of snails in the laboratory. The best method found for maintaining snails was a modification of that of Taylor and Morley (1948). This consisted of using a sloping grade of clay in the bottom of an 8-inch fingerbowl, covering the lower part of this grade with water and seeding the whole thing with algae. Food, consisting of powdered wheat germ and calcium carbonate, seemed to satisfy the snails. Not much growth and no reproduction was noted on this culture but the snails did survive up to 4 months. With the cooperation of the State Veterinarian and 14 meat inspectors, a survey was made of the distribution of liver flukes in Montana. It was found that liver condemnations totaling 408 were made this year from 189 ranches in Montana from F. hepatica infection, and 11 condemnations of livers were made from 7 ranches due to F. magna infections.

In 1962 this work with Montana was discontinued and a cooperative agreement on bovine coccidiosis was drawn up to replace it with the Montana Agricultural Experiment Station.

H. Effect of Intestinal Roundworms on Metabolism.

In 1961, under a cooperative agreement with the North Dakota Agricultural Experiment Station at Fargo, a study was made on the effect of gastrointestinal nematodes on the wool and sulfur metabolism in lambs. Twenty-five thousand larvae of the Trichostrongylus species were given to each of 8 lambs. Eight lambs were kept as controls. Wool samples from the 16 animals, taken at the initiation and termination of the trial, were analyzed for sulfur content and tensile strength. Plasma protein levels of the animals were determined at 2-week intervals throughout the trial. Ova counts were determined at the terminal stage of the experimentation. The control animals averaged 0.5 ova/gram wet feces. The infected animals averaged 637.5 ova/gram feces.

In 1962, continuing the cooperative research at the North Dakota Station, eight lambs were infected with gastrointestinal nematodes and 8 lambs served as noninfected controls. There were no significant changes in plasma protein levels, white blood cell count, hematocrit and hemoglobin levels. The tensile strength of the wool fibers was adversely affected by nematode infection and the sulfur content of the wool was decreased.

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## SHEEP AND GOAT INSECTS
Entomology Research Division, ARS

Problem. Sheep and goats are attacked by a variety of insects and ticks that are responsible for losses of many millions of dollars annually in reduced weight gains, decreased production and quality of wool, and in deaths of animals from gross attacks and insect-borne diseases. Sheep keds are a particularly serious pest in the northern States and screw-worms in the southwestern States. Fleeceworms, lice, and ticks are important pests wherever sheep and goats are raised. Safer, more effective, nonresidue-forming insecticides are needed to combat these pests. There is a special need to develop systemic insecticides that when given at low levels in feed, salt, or water would effectively control pests of sheep and goats and thereby save growers the expense of rounding up and treating flocks several times a year. New approaches to control, including attractants, chemosterilants, and radiation, should be explored and developed for controlling certain pests, as was done for the screw-worm in the Southeast. The possibilities of controlling insect pests of sheep and goats with insect pathogens, parasites, and predators also need to be investigated. Additional basic studies on the biology of the insects involved are essential for the development of biological and sanitation measures for their control. Research is urgently needed to determine which insects other than sand flies transmit bluetongue and the role of insects and ticks in the spread of other diseases of sheep and goats.

### USDA PROGRAM

The Department has a continuing program involving basic and applied research on insects and ticks which affect the health and productivity of sheep and goats. All of the work was done at Kerrville, Texas. Studies are conducted on the biology, physiology, and food requirements of pests of sheep and goats, particularly the screw-worm and Culicoides gnats, with some attention to sheep keds and lice; on the nature of resistance to insecticides and on the length of time insecticides remain on animal skin and hair; and on the absorption, metabolism, degradation, excretion, and mechanism of action of insecticides on the insects. A recently expanded program is underway to find new ways to control pests of sheep and goats, with special emphasis on chemosterilants, antimetabolites, attractants, and non-insecticidal materials. Efforts are being made to develop adult screw-worm attractants for determining the abundance of natural populations and for use in baits for control. Research is concerned with the development of more effective contact and systemic insecticides and to study and devise sanitation or management procedures to minimize or prevent insect reproduction. Primary emphasis is given to the

evaluation of new materials that leave small amounts of or no residues and to testing of formulations that will prolong effectiveness against insects and minimize toxicity hazards. Studies are conducted to determine the occurrence of residues in tissues of animals treated with insecticides in cooperation with the Animal Disease and Parasite Research Division. A limited program is being conducted on the relationship of insects to diseases of sheep and goats, involving experimental transmission from diseased to healthy animals with various species of insects, and insect surveys in epidemic areas. Current studies are centered on the insect vectors of bluetongue disease of sheep. This work is conducted in cooperation with the Animal Disease and Parasite Research Division.

The Federal scientific effort devoted to research in this area totals 4.9 professional man-years. Of this number, 1.9 is devoted to basic biology, physiology, and nutrition; 1.4 to insecticidal and sanitation control; 0.4 to insecticide residue determinations; 0.4 to insect sterility, attractants, and other new approaches to control; 0.6 to insect vectors of diseases; and 0.2 to program leadership.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 0.9 professional man-years divided among subheadings as follows: Basic biology, physiology, and nutrition 0.3; Insecticidal and sanitation control 0.4; and insecticide residues 0.2.

Industry, especially chemical companies and other organizations, are engaged in research on the formulation and evaluation of insecticides for control of pests of sheep and goats. Industry also cooperates with Federal and State workers in developing information on residues resulting from the use of promising insecticides in connection with label registration. Estimated annual expenditures are equivalent to approximately 5 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Basic Biology, Physiology, and Nutrition

1. Screw-worms. Studies were made on the sexual development, behavior, and genetics of the screw-worm fly. Dissections showed that egg development was synchronous in all ovarioles. For various ages of females, the cytological condition of the nucleus of the oocyte and nurse cells was determined. The males were not vigorous in mating until 4 days old, although mating began when they were 2 days old.

In tests with various numbers of flies in holding cages, optimum longevity occurred when not over 100 adults were confined in 12" x 12" x 20" cages and when the sexes were kept separate. Excess mating by males and harassment of females reduced longevity.

Intensive efforts were made to develop a genetically distinct strain of the screw-worm fly. A black mutant male, discovered in examining many thousands of adults from scores of strains, was used to begin a black strain. A homozygous black strain was produced in this way, but it proved inferior to normal strains in longevity and mating vigor. New genes were introduced by crossbreeding with normal blue males and after several generations of inbreeding, the new black strain was equal to normal strains in mating vigor and longevity. Other genetic markers are being developed, including one in which the scutellum is fused laterally to the scutum.

Attempts to create a completely synthetic rearing medium for screw-worm larvae have not yet succeeded. However, research has shown that fish flour will serve as a partial substitute for horse meat. Larvae reared for 48 hours on the standard medium (50% horse meat, 30% bovine plasma, and 20% water) completed their development after being transferred to media in which 50, 75, 87.5, and 100% of the horse meat had been replaced with fish flour. This substitution of fish flour for horse meat reduced screw-worm production costs from 21.4 to 8.7 cents per thousand pupae. The pupae produced on the substituted fish flour diet weighed less, but those produced on the 100% substitution lived slightly longer than those produced on the standard medium. In cage tests the small males mated as well as normal-sized males with normal-sized females.

Studies were made on the effects of radiation on sexual development, mating ability, and longevity of the screw-worm. Both sexes were completely sterilized by a dosage of 5,000 r and no eggs were laid; still no eggs were laid when irradiated females were mated to normal males. However, when irradiated males were mated to normal females, normal oviposition occurred, but none of the eggs hatched. A dosage of 2,000 r administered to newly emerged female flies (0-0.4 hours old) reduced ovarian growth by 50%; this dosage had no significant effect on ovarian growth of females irradiated as 5-day-old pupae. Irradiation had little or no effect on ovarian growth of females over 48 hours old. However, oocytes in 4-5-day-old females were damaged more by irradiation than those in 3-day-old females. No difference was noted in longevity of 5-, 6-, and 7-day-old flies irradiated with 7,500 r in one, two or three exposures. The number of dominant lethals and longevity of the adults was unchanged regardless of whether 5-day-old pupae were irradiated with a single dose or equal fractions at

intervals of 8 and 24 hours. Other tests showed no consistent difference in the effects of 1,000 and 5,000 r administered in two equal doses or in a single dose. Three-, 4-, and 5-day-old female flies differed greatly in sensitivity to radiation, but dominant lethals were induced in the oocytes of all three ages. In tests with 5-day-old pupae, which have only oogonial cells, the numbers of eggs deposited by females decreased as the radiation dose increased, indicating that damage to some cells eliminated them from the germ line and that they were not rapidly replaced. Decreased longevity of adults with increased dosage was noted when 4-, 5-, 6-, and 7-day-old pupae were irradiated. All stages showed lower mortality at 2,800 r than at higher dosages.

A dose of 5,000 r produces about 99% sterility when female screw-worms are irradiated as 5-day-old pupae in a well-aerated container. However, the same dosage given in an atmosphere of carbon dioxide produced less than 50% sterility. Further tests showed that irradiation in an atmosphere of 50% carbon dioxide and 50% air produced greater effects than in air alone, suggesting that the capacity of the present cobalt-60 sources could be increased by 38% by irradiating with 5,000 r in 50% air-50% $CO_2$. However, the insects must be held in the $CO_2$-air mixture for at least 30 minutes before, as well as during, irradiation.

Studies were conducted on the absorption, distribution, metabolism, and excretion of $P^{32}$metepa (chemosterilant). Metepa was absorbed faster and excreted more slowly by the stable fly than the screw-worm fly. This may account for the fact that the sterilizing dose of metepa is much less for the stable fly than for the screw-worm fly.

Mature screw-worm larvae released on soil at 73° F. in field cages entered the ground in 3-4 minutes and pupated in 24 hours. Peak emergence of adults occurred 12 days later between 5:00 and 8:00 a.m. The adult flies did not feed and exhibit mating activity until 4 days old. Most adult flies survived for 9 days but very few were alive after 22 days. At lower soil temperature (51° F.) few larvae entered the soil and although many were still alive 1 week later, none had pupated.

In studies on the dispersal and behavior of released (marked) flies, from 0.4 to 10% of the flies were recovered within 25 yards of the release point the first night. Recoveries decreased on successive nights. Dispersion was rapid in some tests, as far as 1 mile in 45 minutes; in others none apparently moved more than 400 yards. Over 90% of the adults were found resting near the tips of leafless twigs within 4 or 5 feet of the ground.

2. Lice. Studies of the fluctuations of normal populations of biting lice on Angora goats indicated that the lice prefer the forepart of the animal body, including the neck. Peak lice populations over a 20-week period starting November 1961 were in mid-December and the latter part of January 1962.

B. Insecticidal and Sanitation Control

1. Screw-worms. Research was continued to develop more effective insecticides for controlling screw-worms affecting sheep and goats. One hundred thirty one new compounds were screened for systemic action by administering them orally and subcutaneously at several dosages to guinea pigs artifically infested with screw-worms. Ten of the materials showed systemic action in one or both types of administration. One compound (Stauffer N-3054) was effective orally at 10 mg./kg. and three (Stauffer N-2310, Stauffer N-2599, and Stauffer N-3055) were effective at 25 mg./kg. All four compounds and one other (Hercules 9699) were effective at 50 mg./kg. subcutaneously; the other effective materials required higher dosages. The screw-worm larvae that survived the screening tests were reared to adults and bred to determine whether the candidate materials produced any sterilizing effects. Of 121 compounds used in this research, 13 adversely affected survival and development of resulting larvae and pupae, or oviposition and egg hatch. The most active compounds and their effects were as follows: Bayer 38636 (5 mg. orally), all male survivors; Shell 7079 (50 mg. orally), no oviposition; Stauffer R-2404 (10 mg. orally or subcutaneously), no hatch; ENT-5734 (100 mg. subcutaneously), adults died without ovipositing; and Dilan (500 mg. orally), no adult emergence from pupae.

2. Sheep Nose Bots. Tests were conducted to evaluate the effectiveness of 20 of the better cattle grub systemic insecticides against nose bots in sheep. Six of the materials were highly effective. Materials giving 100% control of bots were as follows: Bayer 37342 as a 50 mg./kg. drench and at 50 and 100 mg./kg. in feed; Hercules 7522H as a 40 mg./kg. drench; and Dipterex as a 200 mg./kg. drench. These materials were also highly effective at lower dosages but permitted the survival of a few large third stage larvae. Materials giving 95 to 99% control were Baytex as a drench at 25 and 50 mg./kg.; Bayer 29492 orally at 25 mg./kg.; and Famophos orally at 100 mg./kg. Several other materials were highly effective against first and second stage larvae but were ineffective against large third stage larvae.

3. Lice. A number of insecticides were evaluated as dips for effectiveness against several species of goat lice, using one or two infested animals. Complete control was obtained with the following

materials: 0.15% Delnav, 0.1% V-C 13, 0.1% Dilan, 0.05% Zectran, 0.1% Geigy 30493, and 0.1% Stauffer R-1504. Other materials were less effective at the concentrations tested.

Field tests were conducted to evaluate a number of older and promising new insecticides against biting and sucking goat lice. Apparent eradication of louse infestations was obtained with sprays of 0.05% Diazinon; 0.1 and 0.25% Shell 4294; 0.25% Ruelene, V-C 13, and GC 4072; 0.5% Dilan; and Silicon dust SG-67. Sprays of 0.15% Delnav and dips of 0.25% DDT gave complete immediate control but some animals became reinfested in 1 month. Sevin at 0.1% and chlorobenzilate at 0.25% were ineffective. One flock of sheep heavily infested with biting lice was divided into two isolated groups. One group was sprayed with 0.25% V-C 13 and the other with 0.25% GC 4072. Both insecticides controlled the lice. One flock of unsheared Angora goats infested with biting lice was sprayed with 0.25% Sevin; the treatment greatly reduced but did not eradicate the lice. Seven other flocks that had been sprayed with various materials 6 months before were checked for lice at shearing time. The following failed to control the biting lice from one shearing to the next; Dilan (0.5%), Delnav (0.15%), V-C 13 (0.25%), Sevin (0.25%), Diazinon (0.05%), and GC 4072 (0.25%); however, the infestation was very light with V-C 13. Ruelene (0.25%) controlled both the biting lice and sucking lice.

4. Biting Gnats. Lindane, heptachlor, aldrin, and dieldrin were the most effective of 15 insecticides tested in the laboratory for toxicity to larvae of Culicoides variipennis (vector of bluetongue disease of sheep).

5. Ticks and Keds. Efforts were continued to develop more effective insecticides and other materials for controlling ticks and the sheep keds on sheep and goats. Of over 100 compounds screened for systemic effectiveness, only four showed systemic action against ticks engorging on treated guinea pigs. The effective materials, dosages (mg./kg.), and routes of administration were as follows: Rhodia RP-9895, 25 mg. orally and 50 mg. subcutaneously; Hercules 9699, 50 mg. orally and subcutaneously; Stauffer N-2310, 50 mg. subcutaneously; and Zectran, 50 mg. orally.

C. Insecticide Residue Determinations

1. Residue Studies. Limited studies were conducted in cooperation with the Pesticide Chemicals Research Branch to determine the amount of residues in tissues of sheep and goats after treatment with certain insecticides.

Analytical methods were developed for determining the amounts of V-C 13 in animal tissues. The method was based on the alkaline hydrolysis of the compounds and the determination of the corresponding phenols with amino antipyrene. Analyses of tissues from a sheep 2 days after being sprayed with 0.5% V-C 13 showed from 12.3 to 18.7 p.p.m. in the fat, 2.8 in the heart, 2.2 in the muscle, about 1.0 in the kidney and brain, and lesser amounts in the liver and spleen. Additional analyses were made to determine the amount of residues in the fat of sheep and goats at various intervals after spraying with 0.5% V-C 13. One week after spraying residues in the fat averaged 10.8 p.p.m. for goats. No residues were detected after 8 weeks in sheep and goats.

2. Toxicity Studies. Studies were continued in cooperation with veterinarians of the Animal Disease and Parasite Research Division on the acute and chronic toxicity to livestock of insecticides and other materials applied by different routes of administration. A summary of the results is presented for the year. A detailed report will be made under Unit 2, Animal Disease and Parasites.

Extensive tests were conducted to determine the oral toxicity of a number of old and promising new insecticides to sheep and goats. In tests with sheep, Co-ral at 30 mg./kg. and Shell SD 3562 at 5 mg./kg. reduced cholinesterase (ChE) by 60-80%. Dipterex caused visible toxic effects to goats at 300 mg./kg,, but not to sheep or goats at 100-200 mg./kg., with and without 25% polymer. Dipterex plus polymer reduced ChE more than Dipterex alone, but at all dosages ChE was reduced 64 to 100%. DDVP at 150 mg./kg. plus 25% polymer and Butonate at 200 mg./kg. plus 25% polymer caused no signs of toxicity but reduced ChE 77 and 47%. Dimethoate at 25 to 75 mg./kg. with and without 25% polymer produced no toxic symptoms in goats but ChE was depressed from 56 to 100%. A dosage of 150 mg./kg. was lethal. Phosphamidon at 5 mg., GC 4072 at 10 mg., Methyl Trithion and Bayer 37341 at 25 mg./kg., and Bayer 37342 at 50 mg./kg. were nontoxic to sheep but reduced ChE from 49 to 70%. Baytex at 25 mg./kg. was nontoxic, but 50 mg./kg. killed all animals. Both dosages completely depressed ChE.

Dermal applications of 0.25% Co-ral, V-C 13, and GC 4072 to sheep produced no visible toxic symptoms but reduced ChE 57 to 80%. In dip tests with V-C 13 the maximum safe and minimum toxic doses were determined as follows: sheep, 0.5 and 1.0% dip; goats, 0.25 and 0.5% dip. Little or no difference was indicated between sheep or goats shorn or in fleece. In extensive tests with Shell 4294 no symptoms of toxicity were noted in sheep or goats sprayed with 1%. In similar tests with Ruelene, the maximum nontoxic and minimum toxic concentrations were as follows: Sheep 2.5 and 5.0%; goats 1.0 and 2.5%.

When given orally the maximum nontoxic and minimum toxic dosages of Ruelene were as follows: Goats, 100 and 150 mg./kg.; sheep 150 and 200 mg./kg. Bayer 37342, given at 50 and 100 mg./kg. in feed; and at 25 and 50 mg./kg. intramuscularly caused no toxicity. Feeding the material reduced ChE somewhat more than the intramuscular injection.

Tests were also made to determine the oral toxicity of the chemosterilant, apholate, to sheep. Animals tolerated 20 weekly doses of 5 and 12.5 mg./kg. but were killed by 11 weekly doses of 20 mg./kg. A single dose of 50 mg./kg. was lethal. When given intramuscularly, apholate at 5.0 mg./kg. was lethal and at 0.5 mg./kg. death occurred after 11 weekly injections. In studies with lower dosages of apholate given orally, one sheep died after 101 daily doses of 2 mg./kg. each, but two sheep were still alive after 101 daily doses of 1 mg./kg. In general, sheep being treated showed a progress lymphocytopenia, a proportional increase in polymorphonuclear cells, and an overall leukopenia.

D. Insect Sterility, Attractants, and Other New Approaches to Control

1. Screw-worms. Over 250 compounds were screened as chemosterilants against various stages of the screw-worm. About 50 compounds gave sufficiently promising results to warrant further testing. Almost all the effective sterilants were confidential materials that cannot be identified by name at this time. Known materials causing complete sterility were: Apholate, tepa, tretamine, and metepa, applied topically and in adult food; colchicine, 2,6-diaminopurine, and morzid in food; and methiotepa and thiotepa applied topically. One material (confidential) was effective in the larval medium but ineffective by other means of application. Some of the active compounds sterilized either sex; others were effective only when both sexes were treated; still others were effective only on one sex. Tretamine and a number of other materials sterilized all ages of flies, but others were effective against newly-emerged flies.

Over 200 chemicals and other materials were screened at the Texas laboratory for attractiveness to the screw-worm by special olfactometer procedures and by exposing them in beakers in cages of flies. In olfactometer tests, isovaleraldehyde was 10-times as attractive as the liver standard but less attractive than liver in the cage tests. Several additional materials were as attractive as liver, but none was superior. Studies with liver and other materials indicated that light increased attractiveness and that maximum attraction occurred at 95° to 106° F. Materials exposed at 86°-113° attracted two to three times as many flies as when exposed at 67°-80°. Very few flies from 1 to 3 days old responded to attractants. Highest attraction occurred when the flies were 3-4 days old.

2. Biting Gnats. Studies were conducted on the effects of gamma irradiation on Culicoides variipennis gnats, which are vectors of bluetongue disease of sheep. Exposures to 5,000 and 10,000 r failed to produce complete sterilization in the gnats, but both dosages reduced oviposition, more noticably at the higher dosage. Males were more radiation-sensitive than females and old pupae were more sensitive than young pupae. Neither dosage caused mortality of adult gnats. Successive mating tests indicated that males gradually recovered their fertility as the percentage of infertile eggs decreased from 90 to 5-10% between the first and fifth or sixth mating. Females exposed to 15,000, 20,000 and 30,000 r were permanently sterilized but males treated as adults at 15,000 r and as pupae at 20,000 r gradually recovered fertility. Larvae were killed by 15,000 r and young pupae by 30,000 r. Males were capable of mating at least 20 times. Since they tend to recover sterility in time, even after exposure to 30,000 r, higher dosages will be required for permanent sterilization in order to utilize the sterile male release principle of control.

3. Ticks. Preliminary tests were conducted to study the effects of several known chemosterilants on tick molting, longevity, and reproduction. Engorged lone star tick larvae dipped in 1.0% apholate molted to nymphs and then to adults, but those dipped in 0.5% tepa, tretamine, and metepa failed to molt to nymphs. When engorged nymphs were dipped in 0.5% solutions, the percentages of molting were as follows: Apholate, 45; tepa, 70; tretamine, zero; and metepa, zero. All unfed female ticks dipped in 1.0% solutions of these four materials did not engorge. From 40 to 60% of those dipped in 0.5% solutions engorged, though engorgement of those dipped in apholate required 15.5 days, as compared with 11.2 days for control females and those treated with the other chemosterilants. Viable eggs were laid by surviving females treated with any of the four chemosterilants. Considerably fewer treated ticks survived engorgement than untreated ticks. One female from each of the treated groups produced egg masses that failed to hatch or egg masses with a low degree of hatch, but there appeared to be no consistent pattern of sterilization with the chemicals.

Other studies indicated that irradiation at the rate of 1,000 r had no effect on the molting of unfed or engorged nymphal lone star ticks. However, a dose of 2,500 r prevented molting of unfed and 1-day engorged ticks and only 3% of those engorged 1 week molted to adults.

E. Insect Vectors of Diseases

1. Biting Flies and Gnats. Studies were continued, in cooperation with the Denver, Colo. laboratory of the Animal Disease and Parasite Research Division, on the transmission of bluetongue disease of sheep. Eighteen species of biting flies were collected in a trap baited with a living sheep, including five species of Culicoides, four species of Simulium (black flies) and six species of mosquitoes. Eight specimens of Culicoides variipennis were taken in the process of engorging on the sheep. Before shearing, adults of variipennis were seen flying and crawling about the sheep. After shearing, one of them fed by crawling into the short hair covering the belly--the remaining seven fed at a tiny bare area where the sheep's belly was nicked during the shearing. At five ranches where bluetongue occurred, C. variipennis was taken in small numbers.

# PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Graham, O. H. 1961. The primary evaluation of three organophosphorus compounds for possible use in the control of livestock insects. Jour. Econ. Ent. 54(5): 1046-1047.

Hoffman, R. A. and Drummond, R. O. 1961. Control of lice on livestock and poultry parasites with General Chemical 4072. Jour. Econ. Ent. 54(5): 1052-1053.

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## Insecticide Residue Determinations

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Insect Vectors of Diseases

Jones, R. H., Treiber, G. H., and Pickens, M. O. 1961. Equipment for blood feeding and holding large numbers of Culicoides in experiments with sheep. Jour. Econ. Ent. 54(4): 816-818.

## EQUIPMENT AND BUILDINGS USED IN SHEEP AND WOOL PRODUCTION
Agricultural Engineering Research Division, ARS

Problem. Economic conditions are causing farmers to step-up their efforts to reduce production costs and improve quality by reducing labor and modifying environment in livestock production. Labor is an important element in production costs. How to make better use of equipment and to adapt existing buildings and other facilities for more efficient production as herds and flocks are increased in size and farms consolidated are major considerations. Cost of replacement or major improvement of existing buildings that are not suited to modern production methods are serious obstacles. Principles, examples, and techniques for planning more efficient operations are needed both by farmers doing their own engineering and by those on whom farmers depend for advice.

### USDA PROGRAM

This is a continuing program involving engineers and architects conducting basic laboratory investigations, application of laboratory results to a production basis, and development of typical plans for livestock structures. The work is in cooperation with the AH, ADP and ENT Divisions of ARS, USDA, and State Agricultural Experiment Stations, and contributes to Cooperative Regional Projects NC-23, "Farm Structures to Meet Environmental Requirements of Dairy Cattle, Swine and Poultry," S-49, "Genetic Methods of Improving Dairy Cattle for the South," and NE-8, "Essentials of Poultry Housing for the Northeast." Development work on plans is cooperative with all the State Agricultural Experiment Stations and Extension Services. Federal research effort in this area amounts to 11.3 professional man-years of which 0.4 is devoted to sheep.

Sheep shelters have received limited study in cooperation with the California Agricultural Experiment Station and plans for sheep buildings and equipment are prepared at Beltsville.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Research is underway to determine the operating characteristics of various conveying systems and forage and silage unloading devices and to determine the functional requirements and design of automatic controls for an integrated system for livestock feeding operations. The primary objective of these studies is to arrive at suitable methods and equipment to reduce the labor now required and thus reduce unit cost of production. Some similar work on equipment for swine, poultry, sheep, bees, and milk equipment is conducted in various states.

Industry and other organizations. Most manufacturers of "on-the-farm" equipment for livestock and poultry are engaged in testing the performance of their product design and developing improved products. Some are also investigating farm application of products designed for other uses and a lesser number are developing new equipment or methods to meet specific problems in the livestock and poultry industry on farms. Feed grinders suitable for hard corn in Kansas, for example, are not necessarily satisfactory for soft corn in Minnesota. Research is often conducted on a cooperative basis with electric utilities and with State Experiment Stations to save costs and to obtain nationwide results in testing equipment under a variety of conditions and crops. Industry maintains close contact with USDA research for information on functional requirements and performance characteristics for electric motors, equipment and controls; for example, the motor and control requirements for silo unloaders. The estimated annual industry expenditures for research on items specifically for "on-farm" use are believed to be approximately 10 man-years on poultry equipment, 10 on beef equipment, 10-15 on dairy equipment, 5-10 on swine and less than 5 on sheep equipment.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Plastic-roofed Sheep Shelters. Studies at the Hopland Field Station in California, cooperative with the State station, were continued with the installation of a new cover material consisting of black and white polyethylene film on both sides of heavy kraft paper. A new design of curved roof trusses for low-cost shelters was developed and structurally tested with installation and service-testing planned for next year.

The typical plans for sheep and lamb shelters and feeders and 6 for miscellaneous items of sheep equipment were developed at Beltsville for the Cooperative Farm Building Plan Exchange.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Typical Plans for Sheep Structures

Sheep shed. (Exchange Plan No. 5874.) USDA Misc. Pub. No. 848, May 1961.

Wool packing racks. (Exchange Plan No. 5911.) USDA Misc. Pub. No. 849, May 1961.

Shipping crates for sheep. (Exchange Plan No. 5867.) USDA Misc. Pub. No. 864, August 1961.

Hay and grain feeder for ten sheep. (Exchange Plan No. 5910.) USDA Misc. Pub. No. 865, August 1961.

Weighing crate for sheep. (Exchange Plan No. 5877.) USDA Misc. Pub. No. 873, September 1961.

Sheep feeder and lamb shelter. (Exchange Plan No. 5905.) USDA Misc. Pub. No. 878, October 1961.

Ewe stanchion. (Exchange Plan No. 5912.) USDA Misc. Pub. No. 884, December 1961.

Sheep feeders. (Exchange Plan No. 5913.) USDA Misc. Pub. No. 885, November 1961.

Portable self-feeder for sheep. (Exchange Plan No. 5914.) USDA Misc. Pub. No. 886, December 1961.

Lamb feeder. (Exchange Plan No. 5915.) USDA Misc. Pub. No. 887, January 1962.

Variable-height loading chute. (Exchange Plan No. 5924.) USDA Misc. Pub. No. 888, January 1962.

Mineral feeder for sheep. (Exchange Plan No. 5916.) USDA Misc. Pub. No. 889, January 1962.

Fencing, feeding and creep panels for sheep. (Exchange Plan No. 5917.) USDA Misc. Pub. No. 890, February 1962.

Sheep and lambing shed. (Exchange Plan No. 5919.) USDA Misc. Pub. No. 891, February 1962.

A shelter for sheep (using plastic film). (Exchange Plan No. 5926.) USDA Misc. Pub. No. 894, February 1962.

Grain troughs for sheep. (Exchange Plan No. 5918.) USDA Misc. Pub. No. 899, March 1962.

## II. UTILIZATION RESEARCH AND DEVELOPMENT

### WOOL AND MOHAIR - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. A principal reason why synthetic fibers are making increasing inroads into many of the traditional markets for wool and mohair is that fabrics made from synthetics have certain inherent desired qualities. Some of these are shrink resistance, quickness and smoothness of drying, wrinkle resistance, and ability to hold pleats and creases. Despite the superiority of wool and mohair in tailorability, comfort in wear, appearance and hand, they are lacking in some of the requirements for ease-of-care performance. Moreover, in present processing practices and in many of their uses, wool and mohair are subjected to conditions which result in damage, distortion or weakening of the fibers, and in undesired changes in performance and appearance of fabric.

Needed are practical treatments of wool and mohair to overcome these problems; for example, modifications that give durably wrinkle-resistant lightweight wool fabrics, treated fabrics that are resistant to mussing in wear and in laundering, more resistant to soil. acids, alkalies, wear, pilling, and abrasion; fabrics that have greater resistance to felting and relaxation shrinkage; wools durably resistant to yellowing, to insects, and microorganisms. Needed also are new types of fabrics, woven and non-woven, for industrial and other uses, made from natural wools, blends of wool with modified wools, and with other fibers. Development of new and improved wool and mohair products and processing methods will require fundamental information on the chemical, physical, and structural nature of these fibers. If a stable sheep and wool industry is to be sustained, mills must be supplied with needed processing information on how to produce new and better wool products more efficiently. In addition, inroads have been made in wool markets because of uniformity of price and quality of synthetics and the detailed information which producers of synthetics supply for processing these fibers on textile machinery for wool.

### USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research on wool and mohair is conducted at the Division headquarters at Albany, California, by contract in Dedham and Lowell, Massachusetts; Salt Lake City, Utah; and Washington, D. C.; and by grant funds under P.L. 480 in England, France, and Finland. Fundamental research is conducted on wool and mohair to relate chemical composition and structure, molecular structure, physical structure, physical properties, and surface properties of both normal

and chemically modified fibers to the performance characteristics of the fibers in yarns, knitted andwoven fabrics, and nonwoven forms such as felts. Additional fundamental research is conducted on the chemical modification of wool and mohair to impart resistance to degradation by heat, light, and chemical environments encountered in use, and to improve use properties such as washability, crease retention, wrinkle recovery, and resistance to staining, abrasion, and insect attack. Applied research is conducted to develop practical processes for the chemical or physical modification of wool and mohair fibers, yarns, fabrics, and felts; to develop processing procedures for the modified fibers; and to develop new and improved products from the modified fibers; all to increase the utilization of wool and mohair. Recent development of a practical process for making wool fabrics machine washable is typical of the applied research.

The Federal program of research in this area totals 40.6 professional man-years. Of this number, 17.7 are assigned to chemical composition and physical properties; 13.9 to new and improved textile products, and 9.0 to new and improved textile processing technology. In addition, the Division sponsors 11.5 professional man-years of research under P.L. 480 including 6.5 on basic studies and 5.0 on application of research findings.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations have not reported work on the utilization of wool and mohair in recent years.

Industry is conducting very little research on wool and mohair. With the advent of synthetic fibers, wool processors lost interest in wool per se and undertook processing of the particular fibers that were in demand. Producers of synthetics conducted the research needed to adapt wool machinery to processing of synthetic fibers and furnished the information to the industry. This service, in combination with a serious decline in the financial strength of the wool industry, resulted in a shift of scientists from wool research to quality control, mill troubleshooting, and short range developmental work. U. S. textile machinery manufacturers devote only a small proportion of their research effort to improved wool processing equipment. In summary, wool research has declined seriously over the years, and much of the research effort on wool is pointed toward improving synthetic fibers rather than toward increasing the utilization of wool and mohair. It is estimated that not more than the equivalent of 50 professional man-years are involved in wool research that will benefit the American sheep industry as compared to the equivalent of 2,000 or more professional man-years estimated as being expended on synthetic fibers competing with wool.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Effects of Light and Heat. It is well known that light discolors wool, but it is not well known that light can also bleach wool. Upon exposure to ultraviolet light of wavelength 254 millimicrons, wool first turns greenish yellow, but the green color disappears within a few hours leaving the wool yellow. With longer wavelength ultraviolet light (334 millimicrons), wool yellows without a trace of the fugitive green color. With still longer wavelength ultraviolet light (365 millimicrons),wool yellows first and then bleaches. Visible violet and blue light bleaches wool rapidly. Bleaching occurs similarly in ordinary wool or in wool extensively yellowed by heat or ultraviolet light. Temperature, time, and intensity of irradiation have a complex effect on the colors produced in the wool. Presence of ozone, weave of the fabric, or grease content of the fabric had negligible effect on the color reactions. A better understanding of these color reactions may provide guides for ways of protecting wool against discoloration in use.

Earlier work on the protection of wool from discoloration by light uncovered a number of benzophenone compounds that were effective absorbers of ultraviolet light. It has since been shown that fabrics are protected by these compounds only in amounts that are impractical and uneconomical. The project has consequently been terminated.

Correlation of color changes produced by irradiation of wool with occurrence of free radicals (unpaired electrons) has been revealed by electron paramagnetic resonance spectroscopy (EPR). Many wools have been examined by this technique and found to contain a low but stable concentration of free radicals. The natural free radical is not produced by irradiation because similar concentrations were found in wool from sheep grown in complete darkness for this work by the Animal Husbandry Research Division's Sheep and Fur Animals Research Branch. EPR confirms the finding that irradiation of wool with ultraviolet light produces complex effects. The EPR spectrum of wool irradiated at low temperature persists until the wool is warmed. The spectrum is then similar to that obtained by irradiating the wool at the higher temperature. When wool is irradiated at room temperature and then cooled, the EPR spectrum obtained at the lower temperature is similar to the spectrum measured at room temperature. If wool irradiated at low temperature is warmed and then cooled again, the EPR spectrum measured at low temperature is essentially the same as that measured at room temperature, showing that the change in spectrum with temperature is irreversible.

When wool is exposed in air to ultraviolet light for extended periods,

a substantial part of its weight cannot be accounted for by amino acids obtained by hydrolysis. All of the original amino acids except glycine and alanine are degraded by the ultraviolet irradiation. About half of the degradation products have been identified, the most prevalent being alpha-aminobutyric acid, homocysteic acid, S-methylcysteine, and 1-methylhistidine.

Under contract, an attempt was made to determine the effects of heat on wool, mohair, other proteins, amino acids, and peptides by means of differential thermal analysis. All wool and mohair samples showed only two endothermic peaks, one ascribed to the release of bound water and the other to gross structural breakdown of protein. It was not possible to distinguish among wools or between wool and mohair by the technique.

2. Chemical and Molecular Properties. Basic research on the wool molecule is underway, both at the Western Utilization Research and Development Division, and abroad under P.L. 480 grants. At Albany wool proteins are being fractionated and stabilized, the molecular weights and amino acid compositions of the various fractions are being determined. Results related to molecular weight are being calculated by the Computing Center, Agricultural Research Center, Beltsville, Maryland. In France, a study is in progress to determine the sequence of amino acid building blocks in proteins of wools selectively degraded under controlled acid conditions. The purpose is to determine how chemical structure is related to quality differences among wools. Much of the work to date has been concerned with separation of constituents of the wool fiber with minimum alteration of the chemical structure. In England, a study is in progress to establish the role that sulfur plays in the unique characteristics of wool. From 10 to 15% of the sulfur content of wool cannot be accounted for by ordinary analysis. The investigators have been able to isolate a partial oxidation product containing sulfur from wool hydrolysates but have been unable to identify the product because of its lability. Other research in England involves measurement of self-diffusion of ions of various sizes into keratin proteins under conditions that reveals protein structural differences. This work is yielding new information and may ultimately lead to improved methods for chemical treatment, chemical modification, and dyeing of wools.

The technique of proton magnetic resonance spectroscopy (PMR) yields information on the location of protons or hydrogen nuclei in molecules. The relatively high capacity of wool to bind moisture is one of its important characteristics, but the mechanism of moisture binding is poorly understood. PMR is yielding information on the location of water in wool. For example, with wool containing 10% moisture, the water seems to be bound in clusters to the wool structure and to undergo surface migration. Additional studies are in

progress on PMR spectra of relaxed and stretched dry wools and on amino acid constituents of wool, particularly glycine and glycines deuterated in various positions. The latter will help in the interpretation of the complex PMR spectra of wool. This work may lead to an understanding of the variation of mechanical properties of wool with moisture content.

3. Measurement of Fiber Fineness. Wool fiber fineness and fineness distribution, an essential part of processing research, have routinely been determined by standard microscopic methods followed by calculations requiring approximately 20 minutes. This time has been reduced to 2 minutes by development of a special type graph paper to calculate results. A more precise method which utilizes a Coulter Counter, an electronic device for measuring particle size and size distribution, has been adapted to determination of fiber fineness and fineness distribution. Operating conditions have been established and the reproducibility and error in the instrument have been defined. Analysis of the data shows that the instrument provides accuracy and precision equivalent to that of the best operators using the standard microscopic method, without the inherent subjective error in the standard method. The standard microscopic method requires two to three times longer than the Coulter Counter to measure the fineness and fineness distribution of the fibers in a sample of wool.

4. Mechanical Damage to Wool. The way in which abrasion and wear break down wool structure is poorly understood. Electron paramagnetic resonance spectroscopy (EPR) is yielding information that helps to explain wear and abrasion. When wool is abraded, the concentration of free radicals is increased as is the case when wool is exposed to light or heat. If wool is severely damaged, i.e., ground to a powder, the EPR signals are similar to those obtained when wool is exposed to ultraviolet light of short wave length or to X-rays. Conventional processing operations such as carding or drawing increase the intensity of the EPR signal. Both the irradiation and mechanically-induced free-radical signals disappear if the wool is annealed at 100° C. for several hours, allowed to absorb substantial amounts of water vapor, or wetted out in water. The free radicals arising from irradiation or mechanical damage are believed to be associated with the amino acids, tyrosine and cystine.

5. Physical and Mechanical Properties. Measurements have been made of the frictional properties of wool fibers after application of the WURLAN or IFP polyamide treatment. (See paragraphs B-1 and C-1 of this area report for treatment details.) It was found that the surface friction of the treated fibers was much higher than

that of untreated fibers, but the differential friction (with and against the scales of the fiber) was the same for treated fibers as for untreated fibers. In the past, shrink resistance in a wool fabric has been attributed to reduction of differential friction by various means. Present results show that shrink resistance can be obtained without changing the differential friction. A simple treatment of felting shrinkage as affected by surface friction has been useful in describing the rate of felting of loose top into a ball. (See paragraph C-2 of this area report.) A similar interpretation provided semi-quantitative results when applied to fabric shrinkage, but the effect of agitation introduced a complexity that has not yet been resolved.

Research is in progress on the dynamic mechanical properties of keratins toward defining the interrelations among temperature, moisture content, and frequency. Measurements of the rate of damping of a fiber-supported torsion pendulum show two regions of interest. One, at about -100° C., is due to water bound strongly to the keratin lattice, contributing to a 10% decrease in modulus of elasticity. The other, occurring from 50° to 200° C., depends upon moisture content, and involves a decrease in modulus of elasticity as much as 90%. This is related to loosely-bound water and reflects the great effect of water on mechanical properties.

B. New and Improved Textile Products

1. Shrink Resistant Fabrics. Research has continued on a technique known as interfacial polymerization (IFP) for applying polymers to wool top, yarns, and fabrics. The primary purpose is to make wool fabrics that are fully machine washable, although muss resistance, improved abrasion resistance, and other improvements can be obtained from the treatment. One of the first polymers tested, poly(hexamethylene sebacamide), has given results as good or better than more than 20 other polyamides that have been evaluated. The IFP technique has also been used for applying a wide range of different polymers to wool fabrics, including polyurethanes, polyureas, polyesters, polycarbonates, and copolymers. Several of the polyurethanes have, in preliminary tests, shown results comparable to those obtained with poly(hexamethylene sebacamide). This research will continue because polyurethanes are potentially cheaper than poly(hexamethylene sebacamide). Evidence is accumulating that the IFP polymers are grafted to the wool, a factor contributing to the durability of the treatment. By addition of appropriate chemicals to the solutions used for the IFP treatment, it has been possible to impart shrink resistance, mothproofness, and water repellency to wool fabrics in a single treatment. Tests show that fabrics stock dyed with chrome and neutral premetallized dyes are usually resis-

tant to bleeding and shade change during IFP treatment. Milling dyes should be applied after the IFP treatment. In most cases fabrics can be dyed satisfactorily after application of poly(hexamethylene sebacamide). The IFP treatment ordinarily has little effect on the washfastness or lightfastness of dyes. The process for applying the IFP to fabrics is described in paragraph C - 1 of this area report.

The epoxy-polyamide treatment for shrink resistance has been shown to be less suitable for most fabrics than the IFP polyamide treatment. In consequence, research on the epoxy-polyamide treatment is being limited to fabrics such as blankets where the treatment can be applied in conventional equipment such as dye becks in plants where padders for the IFP treatment are frequently not available. Part of the research on the epoxy-polyamide treatment was done under contract by the Fabric Research Laboratories, Inc., Dedham, Massachusetts. Results included comparison of padding and exhaustion as methods of applying the resin, effect of fabric construction on shrink resistance and handle of the treated fabric, and analysis of causes of stiffness in treated fabrics.

2. Chemical Modification of Wool. Research is continuing on chemical modifications of wool to impart new properties. For example, greater resistance to acids and alkalies could lead to new industrial uses for wool. Both dimethyl sulfoxide and dimethylformamide are good solvents for reacting wools with a variety of acylating reagents. Wool reacted with isocyanates has shown increased resisance to acids, alkalies, and hypochlorite, dye resistance, and, in some cases, shrink resistance. In a series of n-alkyl isocyanante-modified wools, it was observed that the alkali solubility of the treated wool decreased with increasing alkyl chain length in the isocyanate. In general, diisocyanates impart more chemical resistance to wool than monoisocyanates. Isocyanates will react with wool in gamma-butyrolactone but at slightly slower rates than in the two solvents mentioned above. Wool has also been reacted with a variety of organic acid anhydrides. Wool thus modified is more resistant to acid and less resistant to alkali than untreated wool. At high uptakes, the alkenylsuccinic anhydrides impart moderate shrink resistance to wool. Wool has also been modified with lauroyl, myristoyl, and stearoyl chlorides, and with adipoyl and sebacoyl dichlorides. Fabrics so treated show decreased resistance to hot alkali, increased resistance to hot acid, and shrink resistance at high uptakes as compared to untreated wool. Although some of the chemical modifications outlined above improve certain properties of wool, none appears to have commercial potential. Problems include the need for hot, anhydrous, organic solvents, polymeric products from side reactions, and loss of strength and resilience in the wool.

3. Durable Creases in Wool Fabrics. As part of a program to improve wool's easy-care properties, processes have been investigated for imparting durable creases to wool fabrics. Although a wide variety of chemicals have been screened, including cross-linking agents for reduced wool, ethanolamine in dilute aqueous solution performs as well or better than other agents tested. No fully satisfactory treatment is now available for durable creasing of wool. Ethanolamine sulfite, independently recommended by the Wool Bureau, has little effect on fabric color, but the treated fabric develops an odor upon wetting. Ethanolamine does not cause an odor problem, but tends to yellow the fabric slightly and to make a slightly harsh crease. Nevertheless, the Quartermaster Corps had forty pair of uniform trousers durably creased with ethanolamine under our supervision for test. We are informed that the QM is writing specifications for the durable creasing of army trousers with ethanolamine. Development work was also carried out on objective measurement of creases and wrinkles in fabrics. An instrument was constructed that traces the fabric contour and computes any desired factor to describe the crease or wrinkle. Crease shape can be described easily, but no definition of wrinkledness has yet been found that correlates fully with the subjective judgment of a test panel.

4. Treatment of Wool Top for Shrink Resistance. As outlined in paragraph C-1 of this area report, a practical process has been developed for applying the WURLAN or IFP polyamide treatment to woven fabrics and to knitted yardage. The treatment is also effective on knit piece goods such as socks and sweater bodies. However, no practical way has been found for applying the treatment to piece goods. As an alternative, research was initiated on applying the treatment to wool top, using equipment similar to that used for backwashing of top. Considerable success has been obtained, although more developmental study is needed to make the treatment practical under commercial conditions. The treated top spins satisfactorily and the treatment does not seem to affect yarn uniformity. Fabrics knitted from yarns made from treated top show good resistance to felting shrinkage. Since the polyamide film increases the surface friction on the wool fibers, yarns from treated top require less twist for equal strength than yarns from untreated top. This could lead to reduced costs since the production rate of a spinning frame is related to the amount of twist in the yarn being spun. High-twist yarns from treated top can be woven into hard-finished worsteds that show unusual and desirable crispness and handle. Application of the WURLAN treatment to top profoundly affects the fulling properties of subsequent fabrics. Fabrics can be made that show good shrink resistance even though loosely constructed, and fabrics can also be made that cannot be fulled. This work will lead directly to entirely new types of fabrics from wool.

5. Improved Carbonizing of Wool. Under contract with the Harris Research Laboratories, Inc., Washington, D. C., a project was completed on improved carbonizing of vegetable matter in wool. It was found that there are three main factors in the sulfuric acid carbonizing process that govern the degree of strength loss of the wool: (1) the acid content of the wool entering the dryer; (2) the moisture content of the acid-containing wool as the material enters the dryer; and (3) the air temperature used to dry the wet, acid-containing wool. By proper adjustment of these conditions, it was found that burrs could be completely carbonized without causing any measurable strength loss of the wool. It was also shown that the rate of diffusion of sulfuric acid into wool was significantly slower than the rate of sorption of acid onto the burrs, especially when the acid solution temperature is between 50° F. and room temperature. Advantage was taken of this difference in rate of sorption to deposit the required amount of acid on the burrs while a relatively small amount was taken up by the wool. Thus, a new and faster treating procedure, differing from conventional commercial practice in several aspects, was suggested: 7 to 7.5% sulfuric acid in the treating solution, at 50° F., with immersion of the burry wool for 15 to 60 seconds instead of 3 to 7 minutes or more. A further contribution of this research is a clarification of the role of wetting agents in the acid bath. Wetting agents per se do not protect the tensile strength of the wool, but their beneficial effect is a result of their reducing the water content of the extracted, acid-treated wool prior to drying and baking. A number of other factors in processing also were clarified. For example, it was shown that all of the wool damage (loss of strength), if any, occurred during the drying phase of the carbonizing process. There was no further loss in strength after baking provided that the wool was dried to a moisture content below 14% before it was baked. Drying time was not an important factor, but drying temperature was of great importance especially when the wool contained more than 5% acid. The optimum drying temperature was between 130° and 150° F. The optimum baking time and temperature for the dried wool was three minutes at 300° F., when the air velocity in the oven was 400 linear feet/minute and the loose wool was in a layer 1" to 1-1/2" in thickness, and when the acid content of the burr was between 2.5 and 3.0%. As might be expected, fine wools were more easily damaged by carbonizing than were medium or coarse wools. Thus, the fine wools (64 grade and finer) require somewhat milder processing conditions (lower acid content or lower drying temperature) than coarser wools. The contractor's final report presents recommendations for processing conditions applicable to pilot plant and mill trials.

6. Bleaching of Wool. A research contract was initiated at the Lowell Technological Institute, Lowell, Massachusetts, on improved

procedures for bleaching wool. A supply of discolored wool was obtained and portions were processed into top, yarn, and fabric to be used in the project. Exploratory tests have been made on the bleaching of top in which time, temperature, pH, and peroxide concentration were the variables. Measurements were made of the reflectance and alkali solubility of the treated wool, and the consumption of peroxide. The project has not yet reached the stage where broad conclusions can be drawn.

7. Improved Finishing Treatments for Wool Fabrics. Supported by a P.L. 480 research grant in Finland, a study is in progress to determine the influence of different finishing procedures on wool fabric properties, and to develop a finishing procedure that imparts to the finished fabric optimum properties with regard to appearance, handle, and tailoring and weaving qualities. The experimental fabrics for the project are being designed and woven and preliminary dyeing studies are in progress. No conclusions have yet been reached.

C. New and Improved Textile Processing Technology

1. Treatment of Fabrics for Shrink Resistance. A practical process has been developed for applying the IFP polyamide treatment to wool fabrics for control of felting shrinkage. (See paragraph B-1 of this area report for additional discussion of the IFP treatment.) Through statistically-designed experiments, important process variables were identified and evaluated. The treatment is best applied with two padders in tandem. In the first padding step, the aqueous solution of hexamethylene diamine should be heated to the range of 100 to 130° F., and the fabric should be skyed to provide a time lapse of 20 to 30 seconds between immersion and padding of the fabric. The load on the padder rolls should be adjusted to give 50% or less wet pickup of solution by the fabric. Neither solution temperature nor time lapse is important in applying the sebacoyl chloride solution in the second padding step. Under the process conditions specified, fabric has been continuously and satisfactorily treated at rates as high as 25 yards per minute.

The IFP treatment was announced in a new release of October 12, 1960, that brought in well over 100 inquiries. About 150 different fabric samples were treated for manufacturers who expressed interest in the process. Demonstrations of the treatment were held in the Wool Processing Laboratory at Albany, California, and Department scientists supervised mill trials in plants of several major textile producers. A technical conference featuring the IFP process was held at Albany on February 9 and 10, 1961. About 75 people were in attendance. The IFP polyamide treatment has since been designated as the WURLAN process.

2. Felting of Wool. Typical woven wool fabrics and nonwoven felts could not be made if wool did not have the ability to felt. However, this characteristic is responsible for the continuing shrinking of wool fabrics during washing. Knowledge of how to promote as well as inhibit felting is obviously important in the development of new and improved wool products. Study of the fulling process has shown that temperature is the most important factor affecting rate of fulling. Periodic interruption of the fulling operation and trap weight had little effect on fulling rate. It was clearly shown that the type of finish produced by fulling depends upon both rate and extent of fulling. Work was continued on a rapid method for measuring the feltability of various wools. The method involves suspension of a weighed amount of wool in a bottle containing the test solution and shaking of the sample for definite periods of time. The wools form balls whose diameters are related to felting ability. Although results show that the method is useful, none of a variety of compounds tested in the felting solutions were found to have a pronounced effect on felting rate. Artificial removal of crimp from wool increased feltability appreciably. The IFP polyamide treatment of wool fibers decreased their feltability markedly.

3. Fabric Construction. Both yarn and fabric construction greatly affect the performance of a fabric as well as the response of the fabric to chemical treatments used to impart easy-care properties. During screening of fabrics from various processors to determine the amount of polyamide required to control shrinkage, all-wool fabrics were found that exhibited from 5 to 75% area shrinkage in our standard wash test. The amount of polyamide required to control shrinkage in different fabrics has ranged from 0.25 to 2.5%, the lower amounts being adequate for some blend woolens and the higher amount being required for hard-twist, tightly-constructed worsteds. It is anomalous that fabrics showing comparatively little shrinkage without treatment require substantial amounts of polyamide for further control of shrinkage. This shows that a truly washable wool fabric should be designed for this specific end use, starting with the construction of the yarn and continuing through construction of the fabric. Similar conclusions have been reached by processors working with other shrink-resist treatments. The WURLAN treatment, however, has controlled shrinkage in a much wider range of fabric constructions than any other shrink-resist treatment.

Further information was obtained on relations among fabric properties and the amount of epoxy-polyamide resin needed to control shrinkage. The study encompassed 19 different fabrics, including woolens and worsted, tight and loose constructions, light and heavy fabric weights, and dyed and undyed samples. It was shown that the amount of epoxy-polyamide resin needed to control shrinkage

is an inverse function of the product of fiber diameter, ends per inch plus picks per inch, and the square root of yarn tex. The coefficient of the equation is dependent upon the dye on the fabric.

4. Uniformity, Strength, and Nature of Yarns. Uniform, strong yarns are necessary for making worsted fabrics, particularly lightweight fabrics. Studies have been made to determine the relations among fiber properties and the uniformity and strength of yarns produced therefrom. A series of yarns was made from fine wool in which twist was the variable. All yarns were of the same count. Twist was varied from the minimum at which the yarn could be spun to the maximum obtainable from the spinning frame (23 turns per inch). The top from which the yarns were made was fully characterized and the final yarns were tested for evenness, strength, and elongation. Yarns of the same count and twist were also made from fine, medium, and coarse grades of wool and were subjected to the same tests. All yarns proved to be of high commercial grade. Yarns from the fine wools showed slightly greater elongation than yarns from the coarser wools, but all yarns were similar in evenness and strength. Fabrics knitted from these yarns showed obvious differences in hand that were not reflected in any of the physical tests.

Two lots of quarter-blood wool, one from Beltsville, Maryland, the other from California, showed distinctly different processing characteristics which were reflected in the uniformity and strength of the yarns spun from the wools. By conventional processing, the Beltsville wool yielded satisfactory yarns, though not outstanding in uniformity and strength. The California wool could not be spun after identical processing because of end breakage. However, when the last pin drafting was omitted in top preparation and a double roving operation performed, the California wool produced more uniform yarns than those made from the Beltsville wool by conventional processing. Our physical tests have failed to explain the observation on processability. The two wools are of similar fineness, crimp, drafting force, and feltability, and differ only 0.4-inch in average fiber length, the California wool being the longer.

A study of the effect of lubricants and waxes on wool yarns is in progress in England with funds made available under P.L. 480. The objective is to relate knitting behavior to lubrication of wool yarns to provide a basis for the development of knitting yarns with improved characteristics and fabrics of improved appearance. To date, work under the grant deals primarily with methodology

5. New Uses for Coarse Wools. The bulk of domestic wools are of coarse grade and are not ordinarily used in suiting fabrics. New

Insert for
Jan. 1963
Progress Report
for Sheep and
Wool RMAC

5. New Uses for Coarse Wools. The coarse grades of domestic wools are not suitable for making fine yarns. New types of yarns from coarse wools or ways of using a higher percentage of coarse wools in blends with fine wools can provide additional outlets for the coarser grades of domestic wools. Attempts are being made to soften wools by chemical modification. Preliminary efforts are encouraging although few conclusions can yet be drawn. Work is also in progress on the blending of WURLAN-treated and untreated wool tops of different grades. New types of yarns and fabrics are anticipated because of the mixture of felting and non-felting fibers. Conclusions in this area of research are not yet available.

types of yarns from coarse wools or ways of using coarse and fine wools in blends can provide new outlets for domestic wools. Attempts are being made to soften wools by chemical modification. Preliminary efforts are encouraging although few conclusions can yet be drawn. Work is also in progress on the blending of WURLAN-treated and untreated wool tops of different grades. New types of yarns and fabrics are anticipated because of the mixture of felting and non-felting fibers. Conclusions in this area of research are not yet available.

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## III. MARKETING RESEARCH

### LIVESTOCK AND MEAT -- MARKET QUALITY
Market Quality Research Division, AMS

Problem. Meat is a very perishable commodity which varies greatly in quality characteristics such as tenderness, juiciness, flavor, and fat content. To insure more uniform grades and standardized products, better objective tests for measuring the quality attributes of meat are needed. Also needed are more effective methods to minimize shrinkage while maintaining optimum quality, bloom, and shelf-life of the product as it moves through market channels.

#### USDA PROGRAM

This work is being conducted at Beltsville, Maryland, with the cooperation of the Animal Husbandry Research Division, ARS, and also in part by research contract with the Universities of Wisconsin and Oklahoma. Research, basic and applied, includes the development of objective methods for evaluating the composition of livestock, carcasses, and meat cuts; the application of ultrasonic techniques to estimate the thickness of backfat and muscling in live hogs, cattle, and sheep, and the use of measurements of the low-level natural gamma-ray emission of meat cuts for estimating their lean content. New techniques for measuring meat tenderness are being developed and evaluated.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years of which 2.4 man-years is by research contract. The total effort is devoted to objective measurement and evaluation of quality. During the report period, work on criteria for identifying meat-type hogs and feeder pigs (BS 3-74) was completed. Studies on gamma-ray measurements of meat cuts (BS 3-5) were also completed.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 8.1 professional man-years divided among subheadings as follows: Objective measurement and evaluation of quality 6.7, quality maintenance in handling, packaging and storage 1.4. The former includes objective measurement of meat quality on beef, lamb, and pork, including physical and chemical changes in fat and protein; changes in color of different cuts of meat; organoleptic evaluation of tenderness;

histological structure; collagen content; and amino acids; influence of pre-slaughter treatment; effects of marbling, fat covering, color maturity, and other carcass characteristics on the basis palatability components. Under handling, packaging, and storage the work concerns maintenance of product color, control of moisture, prevention of off-odor adsorption, and of microbiological spoilage.

Industry and other organizations also conducted research in this area. The American Meat Institute Foundation research program includes various aspects of meat processing, prepared meats, and meat cookery, and amounts to an estimated annual expenditure equivalent to approximately 3 professional man-years. Many meat packing companies have their own laboratories. However, to a large extent, the work of these laboratories is slanted toward the development of new processing procedures, products, and formulations, thus limiting the research effort on evaluation of market quality and quality maintenance. Much of the research of company laboratories in this area is kept confidential. Estimated annual expenditures are equivalent to approximately 8 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Although the following work has not been done specifically with lamb, the objectives and procedures may be applicable.

### A. Objective measurement and evaluation of quality

1. Evaluation of Live Animals in Relation to Composition. Analysis of much of the data from extensive research on the relationship of ultrasonic readings of backfat and muscle thickness of live swine has been completed. Highly significant multiple correlations were found between three or more successive live animal ultrasonic readings of backfat thickness and total separable fat. A highly significant multiple correlation was found between five successive live animal ultrasonic readings of backfat thickness and total lean content.

Research on the use of nondestructive measurements of natural potassium - 40 gamma radiation revealed that natural radioactivity was highly correlated with the percent of separable lean and separable fat of pork hams and beef rounds.

(BS 3-5)

2. Measurement of Tenderness. A new device for evaluating the tenderness of sliced meat has been developed. This Slice-Tenderness Evaluator (STE) was used in conjunction with a standard

commercial testing instrument, in cooperative tests with ARS, to evaluate pork roast slices. The evaluation with the STE were in good agreement with a subjective taste-panel evaluation and a standard objective method which involves the use of meat cores (Warner-Bratzler shear).

(MQ 3-34)

3. Factors Influencing Quality in Pork. A total of 466 carcasses were selected for this study and included animals of known and unknown histories. Marbling in the longissimus dorsi and chronological age were found to be the most important factors associated with palatability. Fresh pork loins were generally acceptable in palatability if they contained approximately 20% of intramuscular fat on the moisture free basis and were from animals less than 220 days of age. The palatability of commercially cured hams was acceptable regardless of chronological age, carcass weight or intramuscular fat content. Bacon became more tender with increasing amounts of intramuscular fat. Flavor and juiciness of bacon were not affected by differences in chronological age, carcass weight, or intramuscular fat. Loin eye area per hundred pounds of carcass weight was of greater value in the prediction equation of lean yield than was unadjusted area of the longissimus dorsi. The gilt carcasses exhibited higher lean cut yields, larger loin eye areas, higher percentages of loin and ham, less backfat thickness and were longer than barrow carcasses.

(MQ 3-9(C)

4. Influence of Bovine Age Upon Meat Characteristics and Grade. The contractor has been evaluating the work of the past 3 years and making statistical analysis of the data. Several publications have already been prepared and several more will be ready in the next few months. Some of the important findings to date are the following: It was found that tenderness of the longissimus dorsi steaks as measured by the Warner-Bratzler Shear and panel (with marbling of each carcass at or closely approaching either the "slight amount" or "slightly abundant" level) decreased significantly with increasing animal age. The greatest difference in tenderness was observed between the 18 and 42 month age groups. The effect of aging the meat 14 days varied with animal age, marbling level, and the tenderness measure used. Moisture, ash, and protein contents of loins were not significantly different for the age groups except that the 6-month old calves had slightly higher moisture values.

(MQ 3-10(C)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Objective Measurement and Evaluation of Quality

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## WOOL AND MOHAIR -- MARKET QUALITY
Market Quality Research Division, AMS

Problem. Wool varies widely in quality factors that affect its value and use. Impurities in grease wool are a major problem, and an objective method of estimating the clean yield of grease wool is badly needed. Also needed are procedures and instruments to measure accurately the fineness and length of fibers. Animal fibers in raw or manufactured form are subject to damage by fabric insects, which are estimated to cause annual losses of about $350 million. Effective and safe control methods are needed to be used in homes, retail stores, warehouses, woolen mills, and manufacturing plants to control the fabric insects that infest the premises. Improved fabric treatments and methods of application are needed to prevent the extensive feeding damage by insects. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information leading toward the development of better preventive treatments, and as an aid to the Western Utilization Research and Development Division in its program on the improvement of wool by molecular modification.

### USDA PROGRAM

The Department has a continuing long-term program at Savannah, Georgia, involving entomologists and chemists engaged in applied research on the protection of wool, mohair, animal hair, and articles made of these fibers against insect damage while in marketing channels, in military uses, and in the home. The research is conducted in cooperation with the Armed Forces Pest Control Board, the Western Utilization Research and Development Division, the Piano Technicians Guild, and various industry groups. Some work on quality evaluation of wool is also done.

The Federal scientific effort devoted to research in this area totals 2.4 professional man-years. Of this number, about 0.1 is devoted to quality evaluation of wool.

Four line projects were discontinued during the reporting period. These were BS 1-55, "Development and Improvement of Formulations and Application Techniques for EQ-53 and Similar Mothproofing Compounds;" BS 1-56, "Development of Measures for Protecting Textiles Against Fabric-Insect Damage while Stored in Containers;" BS 1-57, "Evaluation under Storage Conditions of Fabric Treatments for Protection Against Insect Damage;" and BS 3-60, "Evaluation Procedures for Wool."

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The State Experiment Stations in 1961 reported 1.3 professional man-years on objective measurement and evaluation of quality of wool. Regional Project WM-23, Marketing Wool, is a part of this coordinated research program. Major emphasis is placed on evaluation of the relationship of objective measurements of wool quality factors to processing performance and market value of specific grades and types of western wools.

Industry and other organizations, specifically textile companies and firms in the wool industry, have some research and development personnel working on

aspects of wool quality evaluation. The results of much of this work are kept confidential. Estimated annual expenditures are equivalent to approximately 5 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement and evaluation of quality.

1. Evaluation Procedures. This project has the objective of developing improved procedures for evaluating the market quality of wool. Measurements that were carried out on the gamma-ray emission of grease wool fleeces sheared in Spring 1960 and Spring 1961 disclosed that potassium-40 was the major source of the emitted radioactivity. Cesium-137, a fission product arising from radioactive fallout, occurred in variable amounts in these fleeces. The scouring process removed the bulk of the gamma-ray emitters present in grease wool. The potassium-40 and cesium-137 emission rate did not appear to be closely related to the total content of impurities in grease wool fleeces. Measurements made of grease wool sheared at Beltsville in November 1961 revealed the presence of mixed fission products from fresh fallout, in contrast to wool which had been sheared on earlier occasions, in which cesium-137 and potassium-40 were the principal gamma-ray emitters. The presence of these mixed fission products in appreciable amounts complicated the situation and made it more difficult to obtain potassium-40 measurements.

The wool staple-length recording device for measuring length of grease wool staples which was developed under contract was field tested by personnel of the Livestock Division Wool Laboratory. The performance of this machine, which measures 100 staples of 3-inch wool in about 12 minutes, was found to be very satisfactory. In repeat measurements, the average seldom varied more than 0.03 inch and never as much as 0.10 inch. (BS 3-60)

### B. Prevention of insect infestation.

1. Insecticide Evaluation. Diazinon applied to woolen cloth under simulated dye-bath conditions was highly resistant to removal by 10 drycleanings. After these cleanings, the treatment in the cloth still prevented all warp damage and all but very light to light nap damage by fabric insects in the standard forced-feeding test. Telodrin applied in the same manner was even more resistant to removal by 10 drycleanings or launderings, preventing all warp damage and all but very light nap damage. (BS 1-55)

A formulation containing DDT, Strobane, and lindane, and another containing only DDT and lindane were tested extensively in the laboratory as potential mothproofing treatments for the felts in pianos. After satisfactory performance in these tests, they were recommended to the Piano Technicians Guild for evaluation of practical performance when used in pianos in homes. This applied test is still in progress by members of the Guild. (BS 1-55)

Studies with emulsifiable concentrates of DDT formulated with various surfactants showed that none of the formulations was significantly superior to EQ-53. Studies on the application of DDT to woolen cloth under simulated dye-bath conditions showed that a relationship exists between immersion time and the

resistance of the DDT deposit to removal by laundering or drycleaning. The longer the immersion period, the greater is the persistence. Preliminary studies on incorporating DDT in a fluorochemical formulation and making application to woolen cloth in a cold water dip in accordance with the manufacturer's directions appeared to increase the resistance of DDT to removal by laundering or drycleaning. Further tests in which simulated dye-bath treatment was made showed an increased fixation of the mothproofer to the wool. (BS 1-55)

Studies were conducted on the application of insecticides to woolen cloth in combination with a number of textile treatments to determine the effectiveness of these combinations in increasing the persistence of the insecticidal deposits. These included interfacial polymerization (IFP), shrink-proofing and wool-strengthening treatments, epoxy-polyamide applications, and stain-resistant and water-repellent finishes. None of the combinations were sufficiently superior to the insecticide alone to warrant further evaluation. Several of the treatments without the insecticide protected the cloth against insect feeding in precleansing tests, but the protection did not persist after the cloth was subjected to any cleansings. Preliminary studies conducted with dye-bath applications of emulsifiable concentrates of DDT formulated with various surfactants showed that a cationic surfactant by itself may be a very effective mothproofer. One, which contained 98 percent of cetyl dimethyl benzyl ammonium chloride, did not completely protect the cloth in precleansing tests but after five drycleanings was as effective as the insecticidal treatment used as a standard. (BS 1-55)

Laboratory biological evaluations were completed during the past two years with 114 compounds to determine their efficacy in protecting woolen cloth against fabric-insect damage. Two quaternary ammonium compounds, Ammonyx G and DME, demonstrated sufficient effectiveness to warrant followup studies as mothproofers. These compounds are normally used as emulsifiers, germicides, or deodorants. Residues, deposited by immersing the test cloth in an emulsion bath, showed excellent persistence during drycleaning. The results of preliminary evaluation tests with aldrin and allethrin also indicate need for followup evaluation tests. (MQ 1-26)

2. Insecticidal Control. Military uniforms packed in heat-sealed envelopes made of polyethylene-laminated kraft paper and placed in wooden boxes remained free of insect damage during two years of storage with continuous exposure to fabric insects. The envelopes remained tightly sealed and impenetrable, preventing entry and damage by the fabric insects whether the boxes contained lindane or not. The boxes themselves provide no protection against insects. Studies to determine the length of time required to kill fabric insects exposed to various vapor concentrations of DDVP showed the larva of the webbing clothes moth was the most susceptible, followed in order by the larva of the furniture carpet beetle and the black carpet beetle. (BS 1-56)

Tests in which rolls of cloth treated with DDT during the sponging process have been constantly exposed to a heavy insect infestation showed that this treatment continued to protect the cloth satisfactorily after 15 years. Rolls of cloth treated with DDT by QM during sponging, and then packaged in cardboard boxes, were completely free of insect damage after 10 years' storage in an infested area. The third annual inspection of the test on the evaluation of

dieldrin as a dye-bath mothproofing treatment revealed that a few areas of nap damage varying from very light to moderate and slight warp damage were present on a few rolls. This treatment, however, continues to provide a very high degree of protection. (BS 1-57)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Objective Measurements and Evaluation of Quality.

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### Prevention of Insect Infestation.

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## LIVESTOCK, MEAT, AND WOOL - MARKETING FACILITIES, EQUIPMENT, AND METHODS
Transportation and Facilities Research Division, AMS

Problem. Many of the livestock, meat, and wool marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities needed - such as the livestock auction markets, commercial feedlots, and hotel supply houses. Most private firms handling livestock, meat, and wool lack the technological and engineering skills necessary to plan and develop suitable facility layouts and designs and to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency; including the designing of improved plant layouts, which will provide proper arrangement of work areas to minimize travel distances and excess handling, and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used.

### USDA PROGRAM

The Department has a continuing long-term marketing research program involving industrial engineers and agricultural economists engaged in both basic and applied research to develop new and improved work methods, equipment, and facilities for livestock markets, meat wholesalers, and wool warehousemen. Livestock market research is carried on at Washington, D. C. Part of the work in this area is carried out in cooperation with the Toledo Scale Corporation and the Central Missouri Livestock Auction. One project dealing with commercial cattle feedlots was completed and terminated during the year. The research on livestock slaughtering and meat packing wholesaling at Stillwater, Oklahoma is cooperative with the Oklahoma Agricultural Experiment Station. Wool warehouse research is carried on at Washington, D. C.

The Federal effort devoted to research in this area totals 5.3 professional man-years; 2.5 man-years (including 1.4 man-years of contract work) to livestock marketing, 2.0 man-years to meat facilities, 0.3 man-year to wool warehouses, and 0.5 man-year to program leadership.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Equipment Manufacturers. Several manufacturers of equipment for livestock markets (commercial feedlots, auction markets, and terminal stockyards) are engaged in engineering research to develop improved mechanical devices for performing the physical handling (receiving, feeding, selling, weighing, and loading out) and other related operations required in the marketing of livestock. Estimated expenditures and equivalent to approximately 15 professional man-years annually. A number of companies manufacturing equipment for slaughtering, fabricating, and processing meat and meat products also are engaged in equipment development research. A few of these companies also do service type research to develop layouts for specific work areas in various types of plants for the use of their equipment. Estimated expenditures are equivalent to approximately 150 professional man-years. A few manufacturers of equipment used in receiving, grading, storing, and loading out wool are engaged in engineering research to develop improved equipment for reducing wool warehouse labor requirements. Estimated expenditures are equivalent to approximately 2 man-years annually. The estimated total annual expenditures for livestock, meat, and wool engineering and equipment development research are approximately 167 professional man-years.

Livestock Market Operators, Wholesale Meat Distributors, Meat Packers, and Wool Warehousemen. Although livestock market operators do not have organized engineering research staffs, individual market operators occasionally conduct engineering research on specific problems for short durations. The estimated expenditures are equivalent to 2 man years annually. A number of slaughterers, packers, processors, and fabricators of meat and meat products have organized engineering research staffs to develop improved work methods and plant layouts. Estimated expenditures are equivalent to approximately 75 man-years annually. Wool warehousemen do not have organized engineering research staffs but individual warehouse operators occasionally conduct engineering research to develop specific items of equipment. The estimated expenditures are equivalent to 2 man-years annually. The estimated total expenditures of these industry groups are approximately 79 professional man-years annually.

## REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

### A. Automation of Sales Operations on Livestock Markets

At the Central Missouri Livestock Auction Market, Mexico, Mo., a test system for automating sales operations, consisting of a combination electronic load-cell and lever-system scale for weighing livestock, a scoreboard for flashing gross weight and average weights to the audience, a scoreboard for flashing price to the audience, a recorder for transferring sales information from the auctioneer's box to the office, a

computer for receiving sales information in the office and preparing the seller's check, and electrically-operated pen gates were installed. The combination electronic load-cell and lever-system scale is a newly-developed scale for weighing livestock. The scale in the Central Missouri Livestock Auction was tested twice at about 4-month intervals by the Missouri Weight and Measure Division and the Packers and Stockyard Division. On each test, the scale tested out within specified tolerances and has been approved by these two Divisions. Preliminary tests show that when the scale is connected to a computer and a scoreboard, the gross weight and the average weight of a lot of animals are determined in about 5 seconds and flashed to the audience as compared with about 12 seconds when weights are determined by a conventional scale and average weights are calculated with hand-operated equipment. The reduction in the time for making weight determinations reduces the market's total selling time. The price scoreboard also worked satisfactorily. However, the computer failed to receive sale information from the auction box, make the necessary extensions, and prepare the seller's check fast enough to prevent delays in the sale. The computer functioned on about a 35-second cycle whereas a cycle of approximately 20 seconds is needed.

The problem is now being studied to determine what modifications or curtailments in the present plans for automating the sales operation are needed and what types of equipment should be used to accomplish this objective.

The electrically-operated pen gates failed to function with the degree of satisfaction desired. Although the gates opened and closed at the proper speed and stopped when coming in contact with animals without injuring them, when once stopped by animals during the cycle the gate could not again attain the desired speed for opening or closing promptly. The problem encountered will be further studied to determine if the defects in the present engineering design of the gates can be corrected within feasible cost limits.

B. Determining Behavioral Patterns of Livestock

Because of inability to find a qualified contractor, no work was initiated.

C. Developing a Physically Integrated Livestock Marketing and Slaughtering Facility

Work on this project to date has not progressed to the point that significant results can be summarized.

D. Layout and Work Methods for Hotel Supply Houses

At Washington, D. C. a draft of manuscript entitled "Hotel and Restaurant Meat Purveyors Custom Service House - Improved Methods and Facilities" was completed. The studies show that the typical custom service hotel supply house handling 2,600,000 pounds annually could reduce its costs $3.47 per 1,000 pounds by using the recommended work methods and plant layout. A reduction in cost would be incurred in all major operations. The largest reduction in cost is incurred in the loading-out delivery trucks. The cost for loading out is reduced from about $1.77 per 1,000 pounds of meat and meat products with the typical method, to about 72 cents with the improved method. The use of the rack for loading out with the improved method reduces the amount of handling involved. A layout also is suggested for a house handling 2,600,000 pounds of meat and meat products annually, showing a possible arrangement of equipment and work areas, together with a suggestion for expanding the house to handle twice its planned volume. Field work on a similar study for portion control houses has been completed but the analysis of data has not progressed to a point where the findings can be summarized.

E. Layouts and Work Methods for Wool Warehouses

At Washington, D. C. a manuscript entitled "Reducing Costs of Grading Wool in Warehouses" was completed. The report provides improved layouts and work methods for grading both consigned and warehouse-owned wool in a warehouse having a capacity of 1,000,000 pounds. The study shows that the cost of grading consigned wool can be reduced $1.44 per 1,000 pounds and the cost of grading warehouse-owned wool can be reduced 54 cents per 1,000 pounds. In grading both consigned and warehouse-owned wool, all the savings are in the labor cost and are due to the improved layout, the use of labor-saving equipment (primarily clamp trucks and conveyors), and adjustments in job assignments within the grading crew.

Work on a study covering layouts and operations in wool warehouses is underway but has not progressed to the point where significant findings are available.

# IV. ECONOMIC RESEARCH

## ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem. Within most agricultural processing industries rapid and drastic changes in their market organization and practices are occurring. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products. A significant aspect of the problem in marketing is that this type of information must be obtained from firms engaged in business -- in contrast with other types of research where the problem can be transferred to a laboratory, experimental plot, or other simulated situation. Consequently, it requires the cooperation of people engaged in making their living and assisting with marketing economic research on the side, where their own merchandise, facilities, and opportunity for profit and loss to themselves is involved. Another aspect of the problem is that only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

Also, marketing research is increasingly directed toward evaluating present and prospective programs pertaining to agriculture such as the Food Stamp Program and Federal grading activities and to the changing structure of market industries. Changes in programs or market structure may influence the bargaining power of farmers. Marketing research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Area Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

### USDA PROGRAM

The Department has a continuing program to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. Because about 1/2 of the consumer's dollar spent for lamb and more than 4/5 of that spent for wool goes for processing and marketing activities, any increased efficiency in these activities could result in higher prices to producers or lower prices to consumers, or part of the benefit might be shared by both groups.

It covers all economic aspects of marketing from the time the products leave the farm until they are purchased by ultimate consumers. Much marketing research is functional in nature and could apply to a number of commodities. To the extent the research effort devoted to sheep and wool can be distinguished, it is shown in terms of professional man-years in parentheses at the end of the following subareas:

A. Market Potentials for New Products and Uses

This work is directed at the commercial feasibility and market potentials of new or improved meat and wool products, appraisal of their impact on present markets, and of the economic and technical requirements of end-uses. Such evaluation will provide a sound economic base for decisions on commercial development as well as information to guide further utilization research by physical scientists. (1.7 - fibers)

B. Merchandising and Promotion

This is research to evaluate promotional programs to determine: (1) Responsiveness to advertising and promotional activities, and to identify characteristics of products that are responsive saleswise to promotion; (2) relative effectiveness of different promotional techniques or approaches when employed alone or in combination; (3) sales response-promotional investment relationship for selected products; and (4) organizational structure and procedures for optimum control, coordination and effective conduct of program. Another phase of the research program involves analysis of movement and availability data at retail and wholesale levels, and consumer purchase data by family characteristics including regions, rural and urban areas. This research delineates markets and provides producer groups information on movement and market profiles for specific products in planning and executing marketing programs.

Research is conducted to determine the influence on sales and consumer demand of merchandising practices and pricing policies characterizing the marketing of specific commodities at the retail and wholesale levels of distribution. Evaluations are planned so that findings contribute to general principles and standards of performance relating to such factors as methods, type, location and size of displays; type, kind, color and size of package; variety and quality of products; and pricing techniques. Another basic area of research is designed to increase the efficiency of management through improvements in accounting procedures, inventory control, ordering, space allocation, and functional coordination between wholesalers and retailers, and thereby reduce costs associated with these items in the distribution of farm commodities. (1.0 livestock products)

C. Economics of Product Quality

This program of basic and applied research on the economics of product quality includes study of the problems of seven different commodity groups. Work on all commodities is carried on at Washington, D. C. An early contribution made by government to improve the economic well-being of farmers was the establishment of standards for farm products. This assured the dependability of quality and strengthened farmers' competitive position. Knowledge of the impact of government grades on market practices and market structure provides a basis for answers to questions of public policy related to government grading programs. (5.5 - livestock and livestock products; 5.9 - fibers)

D. Marketing Costs, Margins and Efficiency

This is a continuing long-term program. In nearly all studies, close cooperation is maintained with industry and trade groups and with individual private firms that provide essential data from their records and make their plant facilities available for observation in the conduct of various marketing tests. Much of the research is problem-solving in nature with a limited amount of research devoted to development of improved research techniques. Although much of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located in the States. (4.8 - livestock and livestock products; 2.0 - wool)

E. Market Structure, Practices, and Competition

This area of work is devoted to analyzing the competitive positions of commodities; producing areas and farms; and the changes within marketing firms in response to shifts in location and technology of production; changes in demand and location of population; changes in transportation, processing, and marketing methods; development of new products; and changes in agricultural programs.

Market structure and practices research in the livestock industry is oriented toward the changing structure and marketing and pricing practices of wholesale meat distribution systems including meat packers, processors, wholesalers, and purveyors, and chain or independent retailers. It also includes an appraisal of the changes in market structure and pricing practices associated with the emergence of the commercial feedlot, as well as a study of the price formation relationships between country and terminal markets for hogs.

At Raleigh, North Carolina, Ames, Iowa, and Denver, Colorado, cooperative research with the Southern, Northcentral, and Western regions is underway to project the locational changes of livestock and meat marketing insti-

tutions which are to be expected with the growth and locational shifts of population projected during the next 15 or 20 years. (5.7 - livestock; 2.3- fibers)

F. Information, Outlook, and Rural Development

This continuing program is designed to assist the Department in improving the usefulness of its output of marketing information through studies (1) to evaluate the uses made by both private and public users of information; (2) to determine the nature of the primary needs of these users for information; (3) to develop improved means of collecting data, making estimates, and reporting essential information; and (4) to evaluate impacts that information services have on decision-making by farmers, marketing firms, and public and semi-public agencies.

Research on wool is being done to determine the relationships of wool prices to such factors as yield, fineness, and staple length; to establish the essential elements of a feasible classification service; and to evaluate the potential benefits and problems of classification and market information services to producers and others.

The need and adequacy of an experimental wholesale carlot meat market report is under analysis. The report is offered to a group of interior meatpacking points west of Chicago accounting for about 40 percent of the Federally inspected meat in the United States.

The professional man-years of effort expended specifically for sheep and wool is not available.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

A brief but overall treatment of research by States and industry pertaining to sheep, goats, wool, and mohair is included in the "Introduction" beginning on page v. To the extent information was available, the work by States and industry is reported under the following subareas with professional man-years shown in parentheses at the end of each section:

A. Market Potentials for New Products and Uses

Work in Texas is devoted to studying the marketing and utilization practices and problems of the Texas wool and mohair industry to bring about greater efficiency in handling, and to develop new and improved uses of these products. (0.4)

B. Economics of Transportation and Storage

Regional research is currently being conducted on the economics of transportation of livestock and livestock products in the Southern, Western and Northcentral regions. The research projects in this area represent well-integrated and coordinated State contributions to two regional research projects. In the South, with seven States participating, SM-23, "An Analysis of Livestock and Meat Movement in the Southern Region," involves a study of meat and livestock movements which takes into consideration volume, direction and seasonal variation in movement, inefficiencies in movement, and the role of transportation costs and their implication upon the location of production and processing facilities. In the West, eight States are participating in regional project WM-37, "Economics of Transportation of Livestock and Meats in the Western Region." This is concerned with an examination of the structure of rail and truck rates which prevail in the movement of livestock and meats, the equity of rates on inter- and intra- State movements, the costs and efficiency of shipping livestock and meats by truck and rail, and the effect of transportation costs on location of production areas and processing centers. Progress is being made toward combining forthcoming results of research in the South and West on the transportation of livestock and livestock products, with similar research to be conducted in the Northcentral region with perhaps some Northeastern State stations cooperating. In addition to the above, the Missouri station is making an analysis of rail and truck transportation costs for interregional shipments of livestock and meats, and Nevada is conducting research on controlled experiments in shrinkage resulting from transportation of cattle and sheep, and the cost of regain. (9.7 - all livestock and livestock products)

C. Economics of Product Quality

Research on various aspects of the economics of quality and grade of livestock and livestock products is underway in the main livestock areas of the Nation. Several phases are covered by projects pertaining to the quality and grade of live animals and meats, and others involve the quality and grade of wool. Illinois is conducting research on the marketing of hogs on the basis of merit and value based on grading and pricing practices, and the retailing of pork on a graded basis. Ohio is studying the development of improved methods of marketing fleece wools on a quality and grade basis. New Jersey is investigating factors involved in preserving the quality of frozen and cured meats. Arkansas is determining the effect of preslaughter handling of livestock upon carcass quality. Kentucky is evaluating lambs from selected crosses on the basis of muscling and fatness of carcasses. Well-coordinated regional research on wool in the Western States (Colorado,

Montana, New Mexico, Oregon, Utah and Wyoming) is strengthening the marketing system for wool through the use of improved methods, including sale on a merit basis (WM-23, "Improving the Marketing of Western Wool"), and is measuring the relationship between physical characteristics of grease wools by type and grade and processed products and their respective market values. Through two projects, Oregon is developing quality prediction techniques for frozen beef based on carcass traits and consumer preference, and relating quality of beef to certain blood and liver constituents of the live animals. (5.3 - all livestock and livestock products)

Large national meat packers maintain taste panels to study consumer acceptance, evaluate brand and promotional policies, and market test new products. One packer has developed extensive studies of genetic and feeding factors affecting quality of meat and the relation of live animal chacteristics to quality. One large packer has developed pre-slaughter tenderizing process by injection of meat tenderizer, for which effectiveness is being tested. American Meat Institute Foundation is both studying and supporting university study of meat chemistry and value of meat in the diet and health. About 15 man-years are involved for all livestock.

D. Marketing Costs, Margins, and Efficiency

A number of State experiment stations are engaged in research on costs, margins, and efficiency in the marketing of livestock and livestock products. In the Northcentral States, research is centered around increased efficiency in meatpacking plants including optimum combination of products to process, quantitative techniques as a tool in decision-making in the marketing of livestock and livestock products; the potential expansion of livestock marketing and processing firms. The Northcentral States are also cooperating on a study NCM-25, "Adjustments in Livestock Marketing in the Northcentral States to Changing Patterns of Production and Consumption." In the Northeast, the stations are coordinating their research in a regional project, NEM-7, "Factors Affecting the Efficiency of Livestock Marketing in the Northeast," studying factors associated with efficient buying, processing and distributing of livestock and meats. Southern stations are also coordinating their research in analyzing hog and pork movements, with a view to correcting inefficiencies in such movements, and increasing the efficiency of slaughter plant work methods and equipment, plant layout, design and location -- SM-23, "An Analysis of Livestock and Meat Movement in the Southern Region." In the West, the States are engaged in research to determine the economic factors affecting the economic location of markets and packing plants and the effect of different methods on costs and returns, WM-39, "Alternative Marketing Methods for Cattle and Sheep in the West." One station is determining the relative value

of wool containing vegetable matter, the effect upon price, and the quality of processed products. (5.9 - all livestock)

The amount of research conducted by private firms on marketing margins, costs, and efficiency is not known but it probably is small. Only a few extremely large firms can afford the cost of the essential professional research staff. Results of such privately conducted research rarely is published for obvious reasons. But even if results were published, the social and economic benefits of publication would be limited because these private studies tend to deal with special cases and problems and analyses are based mainly on data for a single firm. Thus, the many thousands of smaller marketing firms and the millions of farmers and consumers must depend on results of public-sponsored research.

E. Market Structure, Practices, and Competition

The State experiment stations, representing all regions, are conducting research on market structure and practices and their effect on the marketing of livestock and livestock products. Much of the effort takes the form of well-integrated and coordinated regional research. In the Midwest, ten States are participating in a regional project NCM-25, "Adjustments in Livestock Marketing in the Northcentral States to Changing Patterns of Production." This research will indicate needed adjustments in production to prospective demand and will determine the effect of production, consumption and transportation costs upon the market structure of the industry. Five Midwestern States are completing regional project, NCM-18, "An Analysis of the Changing Pattern of Livestock Markets in the Corn Belt Region." The findings will provide information on marketing channels used by farmers and on practices followed and services performed by marketing firms. Various Northcentral stations are conducting research individually on the spatial and functional aspects of procurement, processing and merchandising facilities for livestock and meats, with special attention to problems of location, structural changes, and economic factors influencing future marketing and processing. States in the Northeast are conducting regional research under NEM-7, "Factors Affecting the Efficiency of Livestock Marketing," to determine the impact of specification production and buying upon livestock market organization and services. States in the South are cooperating in SM-23, "An Analysis of Livestock and Meat Movement in the Southern Region," to determine the volume, direction and seasonal variations in movements and to determine their effect upon efficiencies of the livestock industry. Independently, other Southern State research has to do with the effect of vertical integration upon livestock production and marketing; the returns to livestock producers from alternative market outlets; the impact of new and potential developments on market practices and the quality and supply of meats; and the

effect of present organizational structure upon the marketing system. In the West, States are cooperating and participating on a coordinated basis in regional project WM-39, "An Economic Analysis of Alternative Marketing Methods of Cattle and Sheep in the West." The analysis will show the nature and extent of direct marketing, and costs and returns from different methods of marketing. Other research has to do with the impact of specification meat buying by large retailers on producer returns. (20.9 for all livestock)

Many companies make studies aimed at analyzing the efficiency of their own operations or at increasing their share of a particular market. Such studies do not present the companies with insights respecting their comparative efficiency with other firms within a particular market and within a particular industry as a group. The market structure and practices research is more likely to be done by public agencies because the kind of information needed for worthwhile analysis requires that the identity of individual companies be held in confidence. Private industry cannot accomplish this type of research either because of the problem of the confidential nature of data, or because legal restrictions prevent individual companies from sharing these data on an identified firm-by-firm basis.

F. Information, Outlook, and Rural Development

The adequacy of marketing information on livestock and livestock products is of continual concern to the experiment stations. Kentucky is making an economic analysis of livestock marketing information available in the State to determine what information is available on live animals and dressed meats to farmers and the meatpacking industry, and what additional information is needed to improve the accuracy of pricing these products. The Montana station is also conducting research for the purpose of appraising livestock marketing information available and to formulate needs of livestock producers in the State which when fulfilled will be most useful in decision-making relative to production and marketing problems. (2.2 for all livestock)

The USDA is the principal agency engaged in the collection and publication of marketing statistics and related information for farm products. Only a few private statistical reporting services and trade groups publish limited, and usually highly specialized, types and quantities of marketing information. Even these private groups rely heavily on USDA statistics and estimates in their published reports. The research done by these private firms and groups to evaluate and improve their services probably is extremely limited and results are not published.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE RESEARCH

## A. Market Potentials for New Products and Uses

### 1. Economic Effects of Foreign Material in Wool on Present and Potential Markets

Foreign materials in wool limit potential applications of wool. For example, jute fibers from bags can show up as defects in finished goods. Competition from clean, contaminant-free synthetic fibers in apparel fabrics makes the need for elimination of foreign materials from wools particularly acute. Under a cooperative agreement with WU-ARS and a private firm, research has been conducted to evaluate the economic capabilities of a redesigned shipping container for grease wools in reducing or eliminating jute fiber contamination in wool. Observations of the results of test bag wools through processing into finished wool cloth have been made and identification of foreign materials appearing in test bag lots versus control lots is being made.

### 2. Market Potentials for Interfacial Polymerized Wool (Wurlan) in Textiles

The Department's Wool and Mohair Laboratory has patented and developed the interfacial polymerization, "Wurlanizing," treatment for wool. This treatment prevents felting shrinkage of wool fabric. Wool fabric processed in this way is home launderable. Apparel manufacturers and retailers have indicated a very strong interest in merchandising home launderable wool products. Market research is being conducted to ascertain the possibilities of expanding wool consumption in those apparel lines where the feature of home launderability is likely to be beneficial. Information on the importance of home launderable wool apparel presently is being sought from garment manufacturers and retailers. This process for treating wool fabric is being adopted by several wool fabric mills and should enable wool to compete more effectively with other fibers.

### 3. Market Potentials for Hides and Skins

Hides and leathers have been experiencing increased competition in the leather-consuming industries. Synthetics have been substituted in a number of uses and a new threat exists in the shoe market in the form of a leather-like synthetic being tested by a chemical firm. Analyses are being made of information obtained from suppliers and manufacturers to determine potentials for retaining leather markets through improved physical characteristics and qualities to meet market needs. In addition plans are being developed to appraise alternative markets to leather for raw materials from hides and skins, primarily collagen or gelatin.

B. Merchandising and Promotion

The American Sheep Producers Council has encountered difficulties in coordinating its promotional activities with those of various segments of the distributive trade. In addition, the availability of lamb to consumers at retail has been limited in certain areas. Research appraising the relative effectiveness of two promotional techniques, or approaches, in generating sales and trade support was conducted in areas of relatively high and low lamb consumption. The two approaches evaluated were: (1) The Council's regular program which is designed to create consumer awareness of lamb through media advertising and publicity emphasizing the various uses and nutritive value of lamb, and obtain trade cooperation through a field service force working with packers, wholesalers and retailers; and (2) a cooperative advertising arrangement with retailers in lieu of the media advertising normally conducted by the Council. The Council shared the cost of the portion of the retailers regular food advertisement devoted to lamb. The two approaches were the same in all other respects.

The combined lamb sales for Northeastern and Midwestern cities were 26 percent greater for cooperative advertising and 10 percent greater for the regular promotion program than for comparable periods of no promotional activity by the ASPC. The difference in sales effectiveness for the two approaches was consistent in both areas, and reflected the amount of trade support the two approaches generated. The cooperative advertising was about six times as effective as the regular promotion when measured in terms of the average increase obtained for a dollar's worth of promotion. The percentage increases in sales over no promotion for both approaches was greater in the Midwest, an area of low consumption. But the actual tonnage increases for each of the approaches over no promotion was much greater in the Northeast.

C. Economics of Product Quality

Economic Effects of Distribution of Lamb by U. S. Grades

Findings suggest that Federal grades enhance the competitive position of smaller packers, wholesalers and retailers by providing quality protection (in both procurement and sales), reduced procurement costs and provide a common language for negotiations. The competitive position of packers relative to each other and the nature and structure of the market in which they sell are major determinants of the grading policy they follow. Independent packers (except for kosher killers whose lamb must leave the coolers before it is firm enough to grade)

generally favor Federal grading because it improves their market position. National packers have brand names of their own and oppose Federal grading per se. Wholesalers in all markets tend to merchandise Federal grades principally because the hotel and restaurant trade, now an important part of the wholesaler's business, demands it. Most of the lamb sold at retail in the United States is sold in the 2 major lamb-consuming areas, the Pacific Coast area and the Northeast.

Most of the lamb consumed on the West coast is slaughtered there (mostly by independent packers) and 82 percent was U.S. graded in 1960. This area has grown rapidly in recent years and food distribution channels are more direct, retail stores are larger, and chains are more important, and require a more standardized product. Federal grades are promoted and advertised, and have become widely accepted as a label of quality.

In the Northeast, the national packers are dominant (27 percent of the lamb was U.S. graded in 1960). They actively promote private brands and supply Federal-graded lamb only when it is demanded and usually at a higher price. Food distribution channels and retail outlets here tend to the pattern of 20 years ago with important wholesalers and numerous small retailers. In both the Northeast and Pacific areas, most retail chains and supermarkets follow high- and low-price policies on lamb, many selling as much as 50 percent of their lamb volume in a few special sales. Because they do not feel compelled to go into the lamb market to buy in volume on a regular basis, they are in an advantageous bargaining position relative to packers, even though the market is more concentrated at the packer level.

The 1960 change in Federal grade standards for lamb has increased their use. Those who found U.S. Choice too fat previously are now more satisfied. However, the use of U.S. grades will continue to be largely determined by the changing "balance of power" in each market. Further increases in the importance of independent packers will tend to increase the use of Federal grades for lamb, but under the present market structure the availability of Federally-graded lamb at retail will continue to depend on the policies of the large chains. Federal grades also serve as product specifications which should shape production decisions. Lambs have been marketed earlier and lighter since the change. Market demand increasingly discriminates between quality levels. Producers should not ignore this trend if they wish to maximize the potentials of lamb, whatever these may be. (Me 2-20)

## D. Marketing Costs, Margins, and Efficiency

### 1. Livestock

In the decade 1949 to 1959, marketing margins for red meats increased sharply. Farm-retail price spreads for U.S. choice grade beef widened 57 percent; for pork, 41 percent; and for lamb, 45 percent. While margins for beef increased slightly again in 1960, margins on pork decreased about 9 percent.

Preliminary findings of an analysis of meatpacking costs in a sample of independent packinghouses indicate rising costs for slaughtering and cutting hogs and marketing fresh pork during a period when packer margins were narrowing. Additional detailed analyses are in progress on cost-efficiency ratios and labor requirements in slaughtering, cutting, boning, and shipping operations for pork and beef at representative plants.

In a comparison of prices of beef, milk, and eggs, and industrial workers' wages in the United States and the 12 countries that comprise the Organization for European Economic Cooperation, the labor time required to earn wages equal to the retail prices of these products was substantially lower in the United States than in all of the other countries with the exception of milk in 3 countries. The labor time required to earn enough to pay for a quart of milk in the United States and Sweden in 1955-56 averaged 7.1 minutes, 7.8 minutes for a laborer in Denmark, and 27.2 minutes for a worker in Italy. For eggs, the range in labor time was 19.5 minutes for a dozen eggs in the United States to 130.6 minutes in Italy. On beef, a United States worker had to work 20 minutes to earn enough to buy a pound of beef compared with 31 minutes in Denmark and 116 minutes in Italy. Thus, consumers in the United States fare much better than those in the OEEC countries when it comes to obtaining much for the money they spend on animal products. In general, farmers receive higher prices in the United States for beef, eggs, and milk than do farmers in most of the OEEC countries. However, retail prices and price spreads on these products generally were higher in actual amounts in the United States than in any of the other countries.

A study of pricing and operational efficiency of wholesale meat distribution in Southern California suggests that price uncertainty and inadequate market information contribute to inefficient pricing and distribution of meat. Price variations within grades frequently exceed price differences among grades. Over half of California meatpackers are integrated with commercial feedlots, and packers sold about two-thirds of their output directly to retailers. Los Angeles wholesalers are specialized by volume and type of customer and specialization among independent packers is increasing. The competitive strength of large retailers relative to packers and wholesalers is increasing.

Important technological advances in methods of curing and handling hides have been made in the last 5 years. But many hide-marketing firms hesitate to adopt the new methods and invest in expensive new facilities without adequate information on the costs of curing hides by various methods. In response to this need a technical-economic analysis has been completed on 4 curing methods. Average total costs in 21 plants

in 1962 were: $1.87 per hundredweight (cured shipping weight) in plants packing salted unfleshed hides, $1.59 in plants curing unfleshed hides by agitated brine methods, $2.24 in plants curing fleshed hides by agitated brine and $2.29 in plants curing fleshed hides by the pit cure method. Although pack-salt curing is the lowest cost method for plants curing fewer than 300 hides daily, the agitated brine is much less costly for plants curing 500 and more hides daily. Costs of fleshing hides drop sharply from 16 cents per hide at a daily volume of 400 hides to 12.5 cents at a volume of 1,000 hides a day. The research report on this study will contain many useful details on design of model hide-curing plants, facilities and labor requirements, and cost standards for efficiently operated plants.

2. Wool

The uncertainties arising from wide fluctuations in wool prices can be a substantial cost of marketing wool for all parties involved. Some reduction in effective price uncertainty and hence capital and marketing costs can be obtained, in some cases a reduction of 70 percent, through proper trading (hedging) in futures contracts. Furthermore, such protection through hedging may be improved further at times through the transfer of hedges and through straddle operations.

E. Market Structure, Practices, and Competition

1. Wool

Results of an extensive study of the nature and extent of wool warehouse operations suggest means of improvement. Warehouses vary markedly in size, volume, and operating methods. Many lack (1) adequate volume for efficient handling, (2) suitable insurance at reasonable rates, (3) information on the most suitable facilities and equipment, and (4) adequate classification and market information for effective merchandising. Although capacity and volume were not significantly related, these was a significant relationship between volume and the proportion of gross warehouse income derived from wool. Nearly 50 percent of the 215 million pounds of wool sold at warehouses was merchandised without the aid of grading or other product improvement, and only 33 percent was tested for yield. State and Federal agencies have results to evaluate wool marketing systems and improve market news reports.

2. Livestock

A number of econometric models have been constructed and tested in an attempt to describe the livestock-meat economy and to project current rates of economic change.

Trends in meat distribution by area from 1929 to 1958 show that changed relative importance of packer branch houses, wholesalers, and direct packer sales to retailers reflects closely the development of retail chains and the shift in population centers. Changes in patterns of consumption, distribution, processing, and production of livestock and meat are being analyzed by regions for the United States. The forces leading to these changes are being isolated and measured.

Substantial changes in the structure of the Southern Plains meat industry may be required in the next several years. Marked changes are occurring in population, incomes, retail grocery structure (growth of supermarkets and voluntary and cooperative retail groups), and in the technology of marketing, processing, and merchandising.

In the West, information on interstate and intrastate cattle movements has been assembled from brand and health inspection records. Movement patterns for feeder and fat cattle are being identified and shifts in the patterns are being analyzed. Attention is being given to the development of a framework for determining the factors important in feedlot and slaughter plant locations.

The geographic distribution by substate areas within the Southern region of livestock marketings, slaughter and meat consumption has been analyzed to show market outlets and sources of supply.

Changes in method of sale in the West may affect (1) the structure of cattle prices, (2) costs and returns to feeders who sell to packers at the feedlot versus other methods of selling, and (3) the relation of the growth of large-scale commercial feedlots in the West to methods of sale and market structure for fat cattle.

Country market prices were higher for Good grade slaughter cattle than terminal market prices for the period of 1957-60. Terminal market prices for Choice grade slaughter cattle were higher than those at the country markets for the same period.

The consumers of the Southwest may prefer beef with less fat than the consumers in the Midwest and West. The country markets in the Southwest are stronger markets for Good grade slaughter cattle and the terminal markets in the Midwest and West are stronger Choice grade markets.

An econometric technique, consisting of a series of spatial-price equilibrium models with alternative assumptions on transportation costs and capital restrictions was used to evaluate the effect of changes in transportation costs on the location of slaughter. The model was tested with secondary data then used to generate evidence about adjustments that will be required to meet changes in the livestock and meat industries.

Changes from present transportation-rate structure based on value of product to one based on cost to the carrier of service furnished would decrease transport rates for meat relative to livestock. This would contribute to shifting of slaughter toward areas of surplus livestock supply and away from deficit areas and lead to shorter distances shipped for livestock and longer distances for meats.

Price relationships and price changes at terminal and interior country markets may disclose whether price leadership patterns exist among terminal and interior markets and provide a basis for more effective selection of market outlets by producers.

Numbers, sizes, and other characteristics of Southern California meat packers and wholesalers may be such as to explain some problems in supplying and pricing beef for that area. Southern California packers and wholesale meat distributors were asked about their supply sources, production, sales and inventories by price and grade, and retail food chains were asked about specifications, purchases, and price paid for meat by grade.

More than half of California packers were integrated with commercial feedlots. Packers sold two-thirds of the meat direct to retailers. Los Angeles wholesalers were specialized by volume and type customers. Packers' branch houses had decreased; number and specialization of independent packers and beef breakers increased. Changes in structure and meat wholesaling were influenced by development of chain stores and commercial feedlots. Competitive strength of large retailers has increased relative to packers and wholesalers because of their volume, specification buying, capital resources and alternative supply sources. Uneven purchases by retailers and uneven flow of fed cattle and carcass beef through marketing channels affected prices. Price uncertainty and inadequate market information contributed to inefficient pricing and price variation within grade often exceeded that between grades.

3. Hides.

Meat packers cure 61 percent of the total hide supply and sell the remaining 39 percent on a green weight basis to hide dealers. However, about 85 percent of all hides are marketed through hide dealers or brokers and the remaining 15 percent are sold by packers to tanners. Analysis of secondary data indicates that labor is the largest single cost item in marketing leather products. Labor accounts for half of the total curing costs, 60 percent of tanning costs, 61 percent of shoe manufacturing costs, and 25 percent of retail selling costs.

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## CONSUMER PREFERENCE AND QUALITY DISCRIMINATION-- HOUSEHOLD AND INDUSTRIAL

Statistical Reporting Service

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increase returns to growers.

### USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine: attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

In addition to surveys of consumer preferences and discrimination, the Special Surveys Branch also provides consultants and conducts special studies, upon request, for other agencies within the Department of Agriculture or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies.

The work of the Branch is carried out in cooperation with other Federal governmental agencies, divisions within the Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land grant colleges, agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D.C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years under regular program funds; of this total, 6.8 professional man-years were devoted to consumer preference research and .2 professional man-years were devoted to quality discrimination research. An additional 2.2 professional man-years were devoted to research conducted under transfer of funds arrangements.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Agricultural Experiment Stations. The Stations do not report any of their work under this heading. However, they do have a considerable program in the area of consumer buying and use practices and motivation and decision making. This includes some research in preference and quality discrimination. There is a reference to parts of the stations' program in other division reports.

Industry and Other Organizations conduct research in this area, but the research done by individual firms and organizations is almost without exception for their exclusive internal use. There are very few instances in which the findings are made public or made available for government reference. In addition to the research actually initiated and paid for directly by industry, a substantial amount is undertaken in their behalf as part of the service provided by their advertising agencies.

Producer Groups: A number of food producer groups conduct consumer preference work with their own staff and, in addition, contract for research with private marketing firms. To a large extent, this research is limited to food classes such as poultry, dairy products, citrus and deciduous fruits (rather than being directed to individual branded products). This research ranges from a small to national coverage. It includes taste testing for quality differentiation, new product acceptance, and attitudes toward existing products. The producers of agricultural fibers have a small but active research program on quality evaluation and consumer preferences, both household and

industrial, for cotton and for wool. Estimated annual expenditures by these groups are equivalent to approximately 10 professional man-years.

Food Processors: In the livestock industry most of the larger packers have research programs for evaluating the effect of product change and acceptance of new meat products. A sizable number of other food processors have extremely large programs of consumer research. They are engaged in work on new food forms and convenience foods such as cake mixes, canned and frozen fruits and vegetables, deciduous fruits, citrus fruits, soups, dairy products, and alcoholic beverages. Manufacturers of cooking oils and shortenings support sizable consumer research programs with their own staff and also under contract. Manufacturers of dehydrated foods, such as potatoes, are constantly engaged in consumer research on their own and on competitors' products. Estimated annual expenditures are equivalent to approximately 400 man-years.

Processors of Nonfood Products: Large programs are supported by all of the major chemical manufacturers, directed to consumer preference and acceptance of synthetic fibers and blends. The three largest textile mills which represent a major proportion of the fabrics manufactured in the United States support research of this type. All of the large manufacturers of cigarettes do research to find out consumer taste preferences for their product; what blends, filters and packages are most likely to succeed in catching and holding a market. Estimated annual expenditures are equivalent to approximately 250 man-years.

Miscellaneous Groups: There is a smaller but constant amount of research undertaken by magazines and publishing houses for their principal advertisers. A number of the largest retail stores in our major cities study the consumers' reactions to their merchandise and service by conducting interview studies with customers and noncustomers. One of the largest food retailing chains has an active program in quality research which involves taste testing as well as consumer preference. Estimated annual expenditures for research related to agricultural commodities and nonagricultural products in competition with them are equivalent to approximately 20 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Consumer Preference

1. Fiber criteria stability. A study conducted in cooperation with the Pennsylvania State University among a sample of homemakers in York, Pennsylvania, has been completed. A report covering the relative importance of certain fiber characteristics in selecting dresses - the first phase of the study - was released in 1959, and has been discussed in previous progress reports.

The second phase of this study was designed to determine the stability, over time, of the respondent's opinions of the importance assigned each fiber characteristic when selecting dresses. In order to assess the stability of the ratings of importance given each fiber characteristic, repeat interviews were made with the original sample of homemakers over a period of several years. The results indicate that there was a high degree of consistency in the individual's rating of a characteristic over repeated interviews, and when individual ratings were averaged there was a notable degree of stability of mean scores over the entire study period. A report covering this phase of the inquiry will be published by Pennsylvania State University. (MD 1-13)

2. Fibers in women's clothes. Final results were published of a nationwide survey of women, conducted under contract, to determine their preferences and reasons for their preferences for fibers in summer skirts, summer suits and dresses, between season dresses, knit dresses, slips and half-slips, summer and winter blouses, and rainwear.

Cotton was the most popular material for the summer apparel studied, and rated well for the garments worn in other seasons of the year. Nylon dominated the picture for both whole and half-slips; wool was the favorite for knit dresses. While appearance and style were leading factors in the selection of a particular garment, ease of care and laundering were the major factors given for preferring a particular fabric for most garments. In appraisals of the general qualities of selected natural and manmade fibers or blends, cotton received more favorable mentions for general qualities such as appearance, comfort, durability, ease of sewing or mending, versatility, and ease of laundering. Comments regarding the newer manmade fibers centered around the wash-and-wear features. Nylon and rayon were the only fibers vigorously criticized. The objections to nylon were chiefly discomfort such as excessive warmth and lack of absorbency, and the effects of static electricity, and lack of durability. Rayon was commented on adversely mainly because of lack of durability and difficulties in care and laundering. (MD 1-34)

3. Fibers in automobiles. Data collection has been completed for a study conducted under contract to determine volume use and preferences among automobile manufacturers for fibers and fabrics in automobile interiors and convertible tops. This study, as a follow-up of comparable studies in 1950 and 1955, is to provide the natural fibers industries with information on changes in the kind and volume of fibers used since 1955, and the reasons for such changes. Preliminary results indicate that the volume of cotton used in autos declined from 1955 to 1961, along with a decline in volume for most of the other materials used, mainly because fewer cars were produced

in 1961. Cotton's share of this market remained about the same, but there were significant shifts in the pattern of use. The proportion of cotton used in seat padding increased, while the proportion used in sidewalls and headlinings sharply decreased. The increased use of paper and vinyls accounted for cotton's displacement in these latter areas.

The preliminary report on volume use of various fibers and fabrics will be released late in 1962. A final report, incorporating both volume data and information on preferences and needs, is being prepared for publication in 1963. (MD 1-49)

4. Fibers in young people's clothes. A contract has been signed for a nationwide survey of the opinions, attitudes, and preferences of teenage boys and girls about cotton, wool, and manmade fibers in selected items of clothing. The purpose of this study is to provide the cotton and wool industries with information on changing attitudes toward and preferences for various fibers so that these industries can direct their laboratory research and public information efforts more sharply toward strenghtening their position with these consuming groups. Planning on this study is complete. Additional work on the study has been delayed by the contractor's loss of key staff and other difficulties. It is hoped that a satisfactory solution to the contractor's problems will be worked out so that field work can be undertaken in 1963. (MD 1-47)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Consumer Preference

Weidenhamer, M. H. 1961. Women's attitudes toward cotton and other fibers in clothing. Marketing Research Report No. 493 (MD 1-34).

## IMPROVING MARKETING OPERATIONS THROUGH RESEARCH WITH FARMER COOPERATIVES
Marketing Division, FCS

Problem. Farmers, in marketing their production, face a revolutionary change in terms of market organization and marketing practices. The ever increasing and important supermarkets require large quantities, good quality, and frequent delivery which the small farmer, working alone, or a cooperative, or local firm of limited size cannot supply. Cooperatives must find ways to consolidate volume, either through internal growth, merger, acquisition or federation to help them meet the needs of mass merchandising. Ways must also be found to reduce marketing costs by increasing efficiency through improved operations, better organizations, and more mechanization.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting the farmers' marketing problems in the modern distribution system. They are organized and operated to increase farmers' net income. Through cooperatives, farmers seek to increase their bargaining power; obtain needed services at cost; improve the quality of farm products; and obtain a larger share of the consumer's dollar. Cooperatives face many problems in achieving these objectives. Research is needed which will assist marketing cooperatives, as well as other marketing agencies, solve their problems by making available essential factual information and developing practical and useful operating plans and procedures.

### USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operations and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The number of Federal professional man-years involved in this work totals 24.8 of which 1.2 are devoted to cooperative marketing of sheep and wool.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations are devoting 6 man-years to research on cooperative marketing. Because sheep are generally sold and processed in the same facilities as other meat animals some of the following work may be applicable.

The work includes 1.5 on livestock and livestock products in Illinois to study corporate and operating structure of cooperative livestock associations, in Vermont to determine the extent to which farmers feel a need for a cooperative livestock auction or other form of marketing cooperative, and in Montana to study the potential of cooperative livestock feeding and marketing associations.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Improving operating methods. Case studies of two wool marketing cooperatives in the Midwest and Southwest have been completed. It was found that the cooperatives could improve their operations and services to growers through new handling methods, use of grading and adoption of the latest knowledge of transporting wool. The wool growers would receive better prices if the cooperatives make improvements in appraising and selling on grade descriptions, use better packaging, use hedging or futures markets and advertise the wool to encourage greater competition from more buyers.

Analysis of wool pools. Preliminary results of this study indicate that about 34,000 wool growers in 32 States marketed 16 million pounds of wool through 239 local wool pools in 1961. The local pools have been organized by growers to obtain higher prices through increased bargaining power accomplished by having larger quantities of wool available for sale. Pools varied widely in volume of wool marketed depending upon the size of the sheep operations in the areas. Pools in the East, South and Midwest States handled on the average 38,000 pounds or 225 pounds per member, while the Western pools averaged 87,000 or 1,250 pounds per member. Local pools have a variety of problems and related opportunities in fields such as: (1) Capable management and loyal membership; (2) returning prices in line with the merit of individual clips; (3) maximizing competition between marketers; and (4) selling ahead of shearing with over and under tonnage for delivery. A manuscript is being prepared to cover the study of wool pools and their operations in the United States.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Stevens, I. M. and Haas, J. T. December 1961. Livestock Pooling--Marketing Through Grading and Commingling. Marketing Research Report 510.

Stevens, I. M. and Haas, J. T. April 1962. Livestock Pooling - An Improved Marketing Method. Article in News for Farmer Cooperatives.

Fox, R. L. September 1961. Recent Developments in Farmer Cooperative Meat Packing and Processing. Information 18.

Randell, C. G. August 1961. A Livestock Market is Born. Gen. Rpt. 96.

Fox, R. L. August 1961. Livestock Marketing Cooperatives in California--Their Progress, Policies, and Operating Methods. General Report 98.

Randell, C. G. January 1961. Livestock Men Work Five Areas for Co-op Success. Article in News for Farmer Cooperatives.

# ECONOMIC AND STATISTICAL ANALYSIS
Economics and Statistical Analysis Division, ERS

Problem: Adequate and accurate information is needed on supplies, production and consumption of farm products, and the effects these and other factors have on the prices of agricultural commodities. Such information is needed in planning operations for the producers, processors and distributors and also benefits the consumer in selecting his purchases. Similarly, accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products are needed by Congress and the administrators of farm programs to effectively evaluate current and future price support and production control programs.

Due to the instability of the prices he receives, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The farmer needs to be provided with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook intelligence and the development of longer range projections of the economic prospects for the principal agricultural commodities.

## USDA PROGRAM

### A. Supply, Demand and Price

In the area of supply, demand, and price the program of basic research into the factors affecting prices, supply, and consumption of principal agricultural commodities has emphasized four broad research areas: (1) measurement of consumer response to price; (2) measurement of the effect of price and other factors on the production and supply of farm products; (3) measurement of the effect of supply and demand factors on farm prices and prices to consumers; and (4) improvement of statistical techniques for measuring economic relationships.

Changes in emphasis are made from time to time to effectively utilize the professional skills available and to adjust to work having the highest priority. The current emphasis is on a comprehensive analysis of the price-making forces in the feed-livestock economy with emphasis on factors affecting supply where relatively little economic research has been done. The research program along these four functional lines is geared to problem areas for individual commodities and related commodity groups. As specific agricultural programs are usually proposed on a commodity basis, the current program is discussed in detail on a commodity basis though much of the actual research is carried on jointly for related commodity groups.

Livestock and Meat. This work involves 1.5 professional man-years located in Washington, D. C. Research on livestock is part of a comprehensive analysis of the price-making forces in the feed-livestock economy. This study gives special attention to the quantitative measures that show what happens to the production of each commodity within the feed-livestock sector following changes in price of one or more of the commodities. The study includes analyses for the United States as a whole and for regions to measure differences in price response and to allow for the important farm and nonfarm alternatives available in each region. The emphasis during the past two years has been on factors affecting the price and supply of hogs. With completion of the hog study, research resources were shifted to a study of the economic factors that affect the supply and price of beef cattle and the demand for feeder cattle and the interrelations among these factors. Results from the beef, hog and feed grain studies along with analyses for milk, eggs and broilers will be incorporated into an overall analysis of the feed-livestock economy.

Cotton and Other Fibers. This work involves 2.0 professional man-years located in Washington, D. C. The purpose of this research program is (1) to measure the influence of economic factors that affect consumption of major textile fibers and (2) to measure the economic factors that affect the price, supply, and utilization of cotton and cotton products. The major effort during the past few years has been on research relating to consumption of fibers. This study provided analyses which make it possible to forecast quantities of cotton, wool, and fiber consumption. With completion of the consumption study research emphasis is now being shifted to analysis of price, supply, and utilization of cotton. Over the years, one of the major outlets for raw cotton has been exports. The study will examine factors causing variation in exports and will develop quantitative relations which can be used for forecasting exports of raw cotton. These, along with the developed equations for forecasting domestic consumption, will improve forecasts of the total utilization of cotton.

B. Commodity Situation and Outlook Analysis

The work in commodity situation and analysis includes the regular publication of 12 commodity outlook reports; the holding of the Annual Outlook Conference in Washington in mid-November; participation of outlook specialists at regional or State outlook meetings or at meetings of farm organizations and agricultural industry groups; preparation and publication of special articles bearing on both the short-run and long-run outlook for farm commodities; issuance of comprehensive statistical bulletins containing the principal economic series pertaining to the various commodities; long-range projections of the demand for the major agricultural commodities; and continuing analysis of the impact of various alternative farm program proposals as they affect output and prices of these commodities.

The total commodity situation and outlook program currently involves 24 professional man-years.

Livestock and Meat. This work involves 3.0 professional man-years in Washington and 2.0 professional man-years in Denver, Colorado. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of livestock and meats. These appraisals are published 7 times a year in the Livestock and Meat Situation, quarterly in the Demand and Price Situation, and the National Food Situation. A comprehensive analysis of the livestock situation is presented at the Annual Outlook Conference. Outlook appraisals are frequently presented at regional or State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply and consumption of livestock and livestock products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Livestock and Meat Statistics, is published annually.

A Western Regional Field Office in Denver, Colorado, conducts a continuing appraisal of the conditions important to the range livestock industry of the West. The results of this activity are published monthly in the Western Livestock Round-Up, supplemented by special releases and special materials circulated to the Extension Marketing Specialists of the Western Region.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Research of State experiment stations in this area is not reported separately but is included with research reported under related areas.

A substantial number of private organizations--including manufacturers of food and fiber products, private commodity analysts, banks, and investment houses--are engaged in commodity outlook work similar to that carried on by USDA. This work, however, frequently related to shorter time periods than those covered by the Department's outlook appraisals; is predominately for private use; and not available to the public. Furthermore, much of the work of the private organizations is heavily dependent on the regular USDA outlook reports and the related statistical material. It is on the whole supplementary to that of the Department, rather than of a competitive or substitute nature. It has been estimated that this type of work in industry and other private organizations may total as much as 200 professional man-years.

A few private colleges and organizations are engaged in price research, and may give attention to agricultural products from time to time. It is estimated that work on agricultural products may involve 5 to 10 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Livestock and Meat. Work on demand and prices for meat consisted of final preparation of a technical bulletin which summarizes some of the findings reported in a previous reporting period. This bulletin records the trends in production, consumption and price of the several meats and meat animals from 1921 to 1960. It seeks to ascertain values for economic factors affecting prices of meat such as supply of meat, income and price level. Factors affecting the demand and production of beef, pork and lamb are analyzed for three subperiods as well as the total period. Changes and similarities among these shorter periods are compared for a better understanding of short-term developments.

A study of the major economic factors that affect the supply and price of hogs has been completed and the results summarized in Technical Bulletin 1274, "Factors Affecting the Price and Supply of Hogs," which is now in press. The hog study develops an explanation of the production and price cycles and measures the relative effect of various factors such as prices of feed, beef and poultry, and consumer income upon the important variables in the hog economy. The variables explained with regression analysis using quarterly data are: (1) the number of sows farrowing; (2) number of hogs slaughtered; (3) quantity of pork produced; (4) cold storage holdings of pork; (5) retail price of pork; and (6) farm price of hogs. Some of the findings from these analyses were that a 10-percent increase in the October-December corn price results in a 2-percent decrease in farrowings the following year. A similar increase in beef prices decreases farrowings by 1 percent. A 10-percent increase in the October-December hog price is associated, on the average, with a 4-percent increase in farrowings the following year. The study also made a special analysis of seasonal variation in the hog industry. The analysis found that the amount of seasonal variation has gradually decreased during the last 10 years because of changes in feeding and production practices. In recent years, peak farrowings also occur earlier than they use to.

The making of price, supply and consumption forecasts and the economic appraisal of alternative programs are two important related aspects of price analysis work. To implement this activity, a 20-equation model for the feed-livestock economy, recently published by G. E. Brandow of Pennsylvania State University in The Interrelations Among Demands

for Farm Products and Implications for Control of Market Supply has been revised to make it applicable to this work. One of the revisions included using a more recent base period--1960. The model was also revised to allow for changes in trends in consumption and price of those commodities which seem to be exhibiting different trends than they were when the model was originally formulated. The revised model is being used as one of the means in providing better estimates in projections work and economic appraisals of the Economic Research Service.

A study of the economic factors that influence the price and supply of beef cattle was recently begun. An analysis of changes in the regional patterns of production of different classes of cattle is underway. Preliminary results from this analysis indicate that formulation of regional supply functions for the various classes of beef cattle will be needed. This is based on the fact that certain factors affecting the supply of beef may be important to some regions, but not relevant to all regions. The influence of these special factors cannot be isolated in a statistical analysis for the United States as a whole.

The situation and outlook analysis indicated that the downward trend in beef prices that started in May 1959 came to an end in 1962. The increase in beef production this year was not sufficient to keep pace with the increase in demand, and fed steer prices reached the highest level in four years. Beef production is expected to increase in 1963 but not sufficiently to weaken prices. Relatively stable levels of pork production the past three years have been accompanied by gradually improving prices. Pork supplies in 1963 are likely to increase sufficiently to reduce prices slightly from this year's level. The liquidation of sheep and lamb numbers (a situation that started in 1960) ended in the first quarter of this year followed by improved prices for this year's lamb crop. Decreased lamb and mutton production is in prospect for 1963 with prices improved over this year.

A shift in the seasonal pattern of prices for several livestock commodities appears to have occurred in the mid-fifties. Current work includes an analysis of between 110 and 120 seasonal patterns of prices and production for various classes and grades of livestock and livestock products. Other work in progress is an analysis of the regional distribution of livestock production and the role of temperature on consumption of meat.

Cotton and Other Fibers. A study of the major economic factors which affect the demand for textile fibers in the United States has been completed and will be published in a technical bulletin in a few months. New statistical series of final domestic fiber consumption were developed as a part of the study. New estimates of consumption were

developed because mill consumption of fibers has recently become an increasingly less satisfactory indicator of domestic fiber consumption. This has resulted because of (1) shifts in the pattern of U. S. foreign trade in textiles, and (2) because of shifts in the mix of fibers used in the manufacture of textiles to include a greater percentage of synthetic fibers which do not displace cotton and wool on a pound-for-pound basis. The new estimates of consumption, which take account of these shifts and the greater utility of synthetic fibers, represent the cotton equivalent volume of fiber used by domestic consumers. These estimates show an upward trend in the post-World War II period, in contrast with the downward trend in mill consumption of fibers. A separate Marketing Research Report was published describing the construction of these new series.

The major economic factors affecting domestic consumption of fibers were found to be the level of real disposable consumer income, year-to-year changes in the level of income and prices of textile fibers. These factors explained about 90 percent of the variation in consumption. The single factor with the most influence on consumption was level of income. It was found that a 1-percent increase in income would be expected to result in a 0.8-percent increase in total domestic fiber consumption per capita. For the individual fibers, level of income was also found to have the most effect on their consumption. For cotton, a 1-percent increase in income would be expected to result in a 0.4-percent increase in per capita cotton consumption. These analysis will make it possible to forecast quantities of cotton, wool, and fiber consumption.

With the completion of the study on factors affecting the demand for textile fibers in the United States, emphasis in research was shifted to a study of price and utilization of cotton and cotton products. Exploratory analyses have been made of factors which affect U. S. cotton exports, including price, foreign production and consumption of cotton, and foreign consumption of synthetic fibers. Exploratory analyses have also been made of the demand for groups of fabrics to gain further insight into the domestic demand for cotton.

Wool Situation and Outlook. The U. S. wool industry experienced a moderate short-term recession in late 1960 and early 1961. During this period mill activity and imports of raw wool and wool textile products declined. Also, commercial stocks were worked down. By mid-1961, the wool industry had recovered from the recession and was beginning to expand quite rapidly. Mill consumption of apparel wools, especially on the worsted system, increased significantly during late 1961 and early 1962. This increase in mill use necessitated an increase in imports of raw dutiable wool. Reflecting this strong mill

demand, wool prices also rose during the period of November 1961 through mid-summer 1962. In addition, imports of semiprocessed and manufactured wool textile products have increased during 1962 from the relatively lower levels of 1961 to near or above the record high levels of 1960.

Dominant factors in the world wool industry during the 1961-62 marketing season were: relatively low raw wool stocks in both the producing and consuming countries; record high levels of consumption; continued firm mill activity; moderately increasing production of wool textile products; expanding foreign trade in raw wool and wool products; a near-record high level of raw wool production; and relatively stable wool prices. At the opening of the 1962-63 marketing season the above conditions continued to prevail. Although these favorable conditions would suggest a shortage of wool and a rise in price, there is little likelihood of any real wool shortage developing or of any substantial price rise because of the increasing availability and use of manmade fibers in blends or pure form.

Analysis of imports of dutiable wool during the last decade reveals significant changes in the quantity, origin, condition, and grade of imports of dutiable raw wool into the United States. Aggregate dutiable raw wool imports have declined. The shares of the total imports have shifted considerably between the 5 major surplus-producing countries of the Southern Hemisphere. The proportion of imported dutiable wool in the scoured condition has increased while that of grease wool has decreased. Imports of dutiable wool grading 60's and finer have increased while those grading 56's and coarser have declined.

New statistical series relating to seasonal adjustments of mill use, domestic consumption of wool, and foreign trade in wool textile products were kept current and published regularly in the Wool Situation. In addition, the research analysis and preparation of the technical bulletin relating to the economic factors which affect mill consumption of wool as well as cotton and manmade fibers was virtually completed. The results will be published in the near future.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Livestock and Meat

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Van Meir, L. W. Livestock and Meat Situation. Published 7 times a year. ERS, USDA, Washington, D. C.

Van Meir, L. W. June 1962. Meat imports rise in first quarter of 1962. Agricultural Situation.

Van Meir, L. W. July 1962. The mid-year outlook for the livestock industry (mimeographed). ERS, Washington, D. C.

Livestock and Meat Statistics. June 1962. Supplement to ERS Statistical Bulletin No. 230.

Breimyer, Harold F. 1961. Demand and prices for meat--factors influencing their historical development. U.S.D.A. Tech. Bul. 1253, 108 pp.

Stanton, B. F. 1961. Seasonal demand for beef, pork, and broilers. Agric. Econ. Research, 13(1), pp. 1-14.

Cotton and Other Fibers

Lowenstein, Frank, and Donald, James R. March 1961. Domestic fiber consumption in cotton equivalent pounds. Cotton Situation, CS-193, pp. 18-27.

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Lowenstein, Frank, and Wittman, Charles H. 1961. Fibers used in textile manufactures entering United States foreign trade. USDA. Marketing Research Report 491, 30 pp.

Lowenstein, F., and Donald, J. E. November 1962. U. S. foreign trade in textiles and domestic fiber consumption in cotton equivalent pounds. Cotton Situation.

Wittmann, C. H. March 1962. U. S. monthly trade in textile manufactures. Cotton Situation.

Wool

Raymond, C. E. Wool Situation. Published quarterly. ERS, USDA, Washington, D. C.

Raymond, C. E. October 1962. U. S. shorn wool production. Wool Situation.

Raymond, C. E. October 1962. Imports of dutiable raw wool. Wool Situation.

Raymond, C. E. 1962. Changes needed in the lamb industry (mimeographed). Presented at Great Plains and Western Outlook Conference, Red Feather Lakes, Colorado.

Wool Statistics and Related Data Through 1961. 1962. Supplement to ERS Statistical Bulletin No. 250.

# V. NUTRITION AND CONSUMER-USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and in the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

## USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition education programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Washington, D. C., and at Beltsville, Maryland; some is done under cooperative or contract arrangements with State experiment stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 61.1 man-years. It is estimated that approximately 13.6 is concerned with studies related to livestock products which includes between 1 and 2 man-years devoted to lamb and mutton.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and micro-organisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research is described on a nutrient basis in the report for the Food and Nutrition Advisory Committee. The total Federal effort is 29.5 professional man-years.

Industry and other organizations such as universities and professional organizations are estimated to devote about 36 man-years to research on the preparation of materials for nutrition education, surveys of diets of individuals, and studies of functional properties and stability of food and of their specific nutrient contents. Limited work is done on the amount and structure of nutrients in foods and on compiling food composition data. Again, some of this work is applicable to this report.

## REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

### A. Nutritive Values of Foods

1. Tables of Food Composition. Data review has been completed for a revised edition of Agriculture Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared." This edition will have nearly 2,500 food items as compared with 751 items of the preceding edition, and upwards of 45,000 separate compositional values. For many foods, data will be provided for different forms--raw, cooked, canned, frozen, milled, dried, instant, dietetic, etc. The new publication will have, in addition to other constituents, data for protein, fat, carbohydrate, five vitamins (vitamin A, niacin, riboflavin, thiamine, ascorbic acid), six minerals (calcium, phosphorus, iron, sodium, potassium, magnesium). Explanatory notes for foods and nutrients will be added for users of the tables. Information on cholesterol and fatty acids will also be included.

   A major expansion of the number of meats and meat products will be made in the revision of Handbook 8. Data will be included for about 175 beef items and beef products. For beef carcass, the composition of six market grades will be shown in the new tables. Retail cuts, trimmed to the retail basis, will be reported for the two most important grades, choice and good, and for each grade as raw and as cooked meat. Data will be given for separable lean and separable fat tissue so that these can be combined in any desired proportions for individual needs. This will provide for variations from the average in retail trimming, and additional trimming in the home.

Data for pork will be shown in a similar way with similar subdivisions but the major classifications will be on the basis of fatness (fat, medium, and thin) rather than market grade. Fresh and cured pork items will amount to 130. Veal will also be classified by fatness rather than grade, over 30 items will be included.

Lamb will be reported under three grades, prime, choice, and good, with detailed information on the four major cuts trimmed to the retail basis. A total of 60 items will be included.

In addition to the major classes of meats, data on most of the edible organs (64 items) will be given, many both raw and cooked. A total of some 40 sausages, cold cuts, and luncheon meats will be included. Data for reindeer, venison, and a few other small game animals will be reported (12 items). Miscellaneous mixed dishes including home-prepared and frozen dishes and dinners will be shown.

2. Vitamin Analyses. Values more representative of the vitamin B6 content of foods now may be obtained by use of a method recently developed at Beltsville, Maryland. Separation by column chromatography of the three forms of vitamin B6 naturally occurring in foods permit each form to be assayed individually. Values derived from these data for total vitamin B6 approximate closely values obtained from rat bioassay.

Research is in progress to combine a number of steps in the determination of various B-vitamins in order to facilitate their simulataneous analyses, permit complete characterization of the B-vitamins in foods and to determine their overall distribution in the food supply.

The vitamin B6 value for dried lean beef muscle tissue as determined by rat bioassay was 13.2. Micrograms per gram as compared to 15.9 by the microbiological assay for pyridoxine, pyridoxal and pyridoxamine. The values for vitamin B6 showed 55 percent pyridoxamine and 40 percent pyridoxal. On a fresh weight basis calves liver contained 5.4 micrograms; beef kidney, 4.5; frankfurters, 1.6; ham, 3.6. These studies are continuing.

Leg and loin cuts of lamb and of pork have been analyzed for thiamine, riboflavin, niacin, folic acid and pantothenic acid. These analyses were part of the studies on paired cuts, raw and cooked, for composition and distribution of nutrients in meats. The lamb data have been included in a manuscript for publication. A manuscript containing data on pork cuts is being prepared.

Pork muscle cuts contained less than 1 microgram of vitamin $B_{12}$ per 100 grams. Frankfurters, beef, veal and lamb muscle cuts contained 1 to 3 micrograms per 100 grams. Products having more than 10 micrograms vitamin $B_{12}$ per 100 grams of edible portion were liverwurst 14; beef kidney, 38; lamb kidney, 63; lamb liver, 104; beef liver, 116. These data have been published.

3. Mineral Analyses. Leg and loin cuts of lamb and pork have been analyzed for content and distribution of mineral elements. These analyses are part of the studies on paired cuts, raw and cooked, for composition and distribution of nutrients in meats. Mineral content of separable lean and separable fat in raw cuts, calculated to milligrams of element per 100 grams of protein showed calcium, copper, iron and sodium were significantly higher in the separable fat on this basis than in the separable lean of both the lamb and pork cuts. A manuscript has been accepted for publication in the Journal of Agricultural and Food Chemistry.

The content of 10 mineral elements was determined in brain, heart, kidney, liver, pancreas (sweetbreads), and tongue of beef, and some in lamb, pork, chicken and veal. The data showed the iron content of the livers of swine and chicken was more than twice that of the livers from ruminants. By far the highest iron values were found in pork liver. Copper content of lamb liver was about three times that of beef or veal and 10 times that of pork or chicken liver. Sodium of pork pancreas was lowest among the organs studied. The data have been published and the studies terminated.

Foods were assayed for mineral element content using the emission of spectrograph for determinations of aluminum, borea, calcium, copper, iron, magnesium, manganese and phosphorus, and the flame photometer for the determinations of sodium and potassium.

B. Food Properties Related to Quality and Consumer Use

1. Lamb. Research to establish the relationship between the age and degree of fatness of animals and the flavor, tenderness, juiciness and the physical and chemical composition of lamb meat has been conducted at Beltsville, Maryland, in cooperation with the Animal Husbandry Research Division of ARS and the Livestock Division of AMS. Results from the study at Beltsville have been published and will be integrated with data on additional animals obtained through contract research at Davis, California.

Meat from the rib-loin was less tender as the age of the animal increased, but leg cuts showed no significant change in tenderness with age of animal. Juiciness and flavor of either rib-loin or leg cut were not associated consistently with age of animals. The amount of separable fat and intramuscular fat did not affect tenderness, juiciness or flavor of the cooked meat. Lean meat from rib-loins and legs of older lambs (11-14 months) contained more intramuscular fat than meat from young lambs (4-5 months). Rib-loin cuts from the older lambs had lower percentages of lean and higher percentages of separable fat than comparable cuts from the young animals. The percentages on lean were about the same in the leg cuts from lambs of different ages, whereas the percentage of separable fat increased and of bone decreased with an increase in animal age. Percentages of drippings increased, and of evaporation losses decreased, with increases in age of animal, amount of separable fat, or size of cut; total cooking losses, however, were similar for all cuts of the same type.

C. Food Economies and Diet Appraisal

1. Food Consumption and Dietary Levels. Information on the nutritive value of the food consumption of households based on the 1955 survey data has been summarized in Report No. 16 of the 1955 Household Food Consumption Survey series. Average family food supplies for a week in 1955 were sufficient to provide more than the National Research Council's recommended allowances for calories and eight nutrients for which values were calculated. However, many households (48 percent) had diets that did not fully meet the allowances in one or more nutrients. Other analyses of survey data show the relation of family size, the education of the homemaker, and of income to the food consumption of households. Because of interest in information on quantities of foods used by high consumers as well as average consumers estimates were made for some 60 food items of the ninth decile--the figure dividing the highest 10 percent of the consumers from the lowest 90 percent. For the meat group, the amount consumed per person in "high consumption" households was nearly twice as much as in "average consumption" households.

Two surveys were conducted cooperatively with the Marketing Research Division, Economic Research Service, in Detroit, Michigan, and Fayette County, Pennsylvania, to provide evidence on the content to which food consumption is increased and diets improved as a result of the Food Stamp Program.

Work is being undertaken on food consumption and nutritive content of diets of individuals. A systematic review and summarization of quantities of food consumed is being made through a cooperative agreement with the Minnesota Agricultural Experiment Station. A similar review of the nutritive content of the diets of individuals is being made by Washington staff.

The nutrient content of the per capita food supply, calculated each year, using data on retail weight quantities of food as developed by the Economic Research Service, provides the only source information on year-to-year changes from 1909 to date.

2. Food Management Practices. Information on the kinds, amount, and nutritive value of foods used and discarded in households has been obtained in a series of small studies. Results will help to evaluate survey data on household food conuumption.

A report on household practices in handling and storing of frozen food has been prepared, based on surveys in Baltimore, Maryland, and Indianapolis, Indiana. Households provided information on the length of time frozen food was held in home storage, and the temperature of the compartment in which frozen food was being held at the time of the interview.

3. Development of Food Budgets and Other Basic Data for Food and Nutrition Programs. An important aspect of nutrition research is the interpretation and application of research findings to practical problems of food selection in relation to health. An ongoing program of work includes assembling and interpreting available information on nutritional needs, food consumption, and nutritional value of foods for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education programs.

A technical report explaining the development of the food budgets, "Family Food Plans and Food Costs," has been completed and is in press. Another in the series of popular publications on food management has been prepared, "Food for the Young Couple." A publication, "Family Food Budgeting...for good meals and good nutrition," designed to help families of all sizes is also being prepared.

Regular pricing of family low-cost, moderate-cost, and liberal food plans is published in Family Economics Review on a quarterly basis for the U. S. average and on an annual basis for the regions and the low-cost food plan for the South. Each plan gives suggested quantities of food that will meet nutritional needs for each of 17 age and sex groups and for women during pregnancy and lactation so that household or population totals may be obtained.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides a channel for disseminating pertinent information and for reporting nutrition education activities. A Nutrition Education Conference sponsored jointly by USDA through its Nutrition Programs Service and by the Interagency Committee on Nutrition Education was held in Washington, D. C., January 29-31, 1962.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Nutritive Value of Foods

Consumer and Food Economics Research Division. 1960. Nutritive value of foods. Home and Garden Bul. 72, 30 pp.

Lichtenstein, H., Beloian, A., and Murphy, E. W. 1961. Vitamin $B_{12}$--Microbiological assay methods and distribution in selected foods. Home Econ. Res. Rpt. 13, 15 pp.

Hopkins, H. T., Murphy, E. W., and Smith, D. P. 1961. Minerals and proximate composition of organ meats. J. Am. Diet. Assn. 38, pp. 344-349.

### Food Properties Related to Quality and Consumer Use

Batcher, O. M., Dawson, E. H., Pointer, M. T., and Gilpin, G. L. 1962. Quality of raw and cooked lamb meat as related to fatness and age of animal. Food Tech., 16, (1), pp. 102-104, 107-110.

Weir, C. E. 1962. Consumer-use qualities of lamb. National Wool Grower, 52, (3), pp. 24-25, 43, illus.

Human Nutrition Research Division. Home care of purchased frozen foods. 1960. Home and Garden Bul. 69, 6 pp., illus.

Human Nutrition Research Division. 1961. Storing perishable foods in the home. Home and Garden Bul. 78, 12 pp., illus.

Demonstrations featuring donated foods in family meals. 1962. AMS-463, 30 pp., illus.

### Food Consumption and Dietary Levels

LeBovit, C., Cofer, E., Murray, J., and Clark, F. 1961. Dietary evaluation of food used in households in the United States. Household Food Consumption Survey 1955, Rpt. No. 16. 55 pp.

Consumer and Food Economics Research Division. 1961. Data on high and average food consumption per person. Radiological Health. 2(3): 119-122.

Reese, R. B., and Adelson, S. F. 1962. Food consumption and dietary levels under the pilot food stamp program, Detroit, Michigan, and Fayette County, Pennsylvania. Agr. Econ. Rpt. No. 9.

Adelson, S. F. 1961. Practical procedures for dietary surveys. Proc. 3rd International Cong. of Dietetics. pp. 158-163.

Nutritive Value of National Food Supply

Consumer and Food Economics Research Division. 1961. Nutrients available for consumption per capita per day, 1909-1960. Supplement for 1960 to Agr. Handbook 62, Consumption of food in the U. S. pp. 43-44.

Consumer and Food Economics Research Division. 1961. Nutrients available for consumption per capita per day 1935-39 and 1947-49. Averages, 1959, 1960, and preliminary estimates for 1961. Table 4. Nat. Food Situation. Rev. p. 20.

Food Management Practices

Adelson, S. F., Asp, E., and Noble, I. 1961. Household records of foods used and discarded--a pilot study in St. Paul. Jour. Amer. Dietetic Assn. 39(6):578-584.

Development of Food Budgets and Other Basic Data for Food and Nutrition Programs

Consumer and Food Economics Research Division. Estimated cost of 1 week's food. In Family Economics Review, ARS 62-5. (USA average issued quarterly, estimated for four regions issued annually.)

Consumer and Food Economics Research Division. 1960. Food and your weight. Home and Garden Bul. 74. 30 pp.

Consumer and Food Economics Research Division. 1962. Proc. of Nutrition Education Conference, Jan. 29-31, 1962. Misc. Pub. 913. (In press)

Nutrition committee news (periodical, 6 issues): July-Aug. 1961, Sept.-Oct. 1961, Nov.-Dec. 1961, Jan.-Feb. 1962, Mar.-Apr. 1962, May-June 1962.

# VI. MARKETING SERVICE AND EDUCATION

## STANDARDS - GRADES - MARKET NEWS
Livestock Division, AMS

Federal grade standards provide a system of market identification of quality differences in products widely identified by buyers and sellers. As trade progressed beyond simple barter, commonly used terms were developed for such factors as numbers, weights, measures, and prices. Grades represent a further step toward accurately describing product differences by identifying quality characteristics for which uniformly understood measures are not otherwise available. This identity is particularly important in the fast-moving, modern business world, in which the buyer and seller often do not meet face to face. Standards for quality originally were developed primarily for the benefit of the producer in making production plans and marketing his product. They also have become increasingly useful to distributors in wholesale and retail trading and to consumers in buying.

A nationwide meat grading and acceptance service on a permissive basis is available to qualified packers and merchandisers of meat upon request. This official interpretation and application of U.S. standards provides a uniform measure of quality, which facilitates the marketing of lamb and mutton. U.S. grades for sheep, lamb, mutton, wool and mohair also are used in the Department's market news reports.

The organizational structure for carrying out the program of livestock, meat, wool and mohair standardization involves the Standardization Branch in the Livestock Division of the Agricultural Marketing Service. The closely allied service functions of applying the standards involves the Meat Grading and Market News Branches in the Livestock Division.

1. Objectives of the Program for Livestock, Meat, Wool and Mohair

The objective of standardization activities is the development of grade standards which are practical and meaningful aids in marketing. The application of more objective criteria, which result in more precise market identification, and which facilitate uniform interpretation and application of the standards, is a continuing goal.

2. How the Program is Carried Out

In the development of grade standards, close contacts are maintained with all segments of the industry in a continuing program of testing and development work designed to provide new or improved standards to meet changing needs. Research results are analyzed and adapted to practical use in standards, considering industry practices and changing production, marketing, and economic conditions. Proposed standards or revisions of standards are published in the Federal Register and comments received from the public are given careful consideration in deciding whether to make the proposals official. Work on wool and mohair standards is conducted at the Livestock Division Wool Laboratory in Denver, Colorado. Work on standards for grades of slaughter lambs and sheep and their carcasses is conducted at Washington, D.C.

3. Activities, Accomplishments, and New Developments

During 1962, the fourth year of a cooperative effort with wool warehouses in the development and application of more uniform preparation methods and standard-type descriptions in marketing wool, more than 2.9 million pounds of wool were involved. The field application of scientific sampling and testing techniques useful in evaluating wool quality characteristics was demonstrated in this program. Reports of tests showing fineness or grade, clean yield, staple length, color, black fiber content, quantity and type of vegetable matter, and other quality factors important in marketing were provided to warehousemen and some growers.

Field testing of an electronic wool staple length recorder, developed in cooperation with the Market Quality Research Division, AMS, and manufactured under contract by the U.S. Testing Company in 1961, was continued in the warehouse demonstrational program. It shows promise of reliable results in objectively measuring staple length. The Port-Ar machine (air flow) for measuring average fineness or grade provides results rapidly in the field work at warehouses. An improved method has been developed for core sampling bales of wool to determine clean yield and has given excellent results. Coring labor is materially reduced by using power equipment to push a core tube into a bale of wool. The amount of sample is reduced materially without reducing the representative accuracy of the sample. The Coulter Counter, an electronic instrument used to measure fineness and variability of wool, has shown great promise as an aid in the rapid determination of grade.

Growers and warehousemen have been keenly interested in the demonstrational program. They feel that the information provided on wool quality places them in a stronger bargaining position in trading.

Many of the test methods used to evaluate wool quality also are easily adapted for use by county agents, livestock specialists, research workers, and others who work with sheep breeders, producers, and market personnel in quality improvement programs.

Micron grade specifications and a method of test for the determination of wool grades have been prepared and cleared through the Bureau of Customs as well as other interested agencies in the Department of Agriculture. These are expected to be published in the Federal Register as proposed revised standards for grades of wool in the very near future.

In 1959 the Sheep and Wool Research and Marketing Advisory Committee recommended that liaison should be established between the Denver Wool Laboratory and the Boston Wool Futures Exchange to coordinate core testing activities. Results for several years were obtained from the Exchange for wools which had been recored when submitted for delivery. This information emphasized the need for improved core testing methods. As a result, improved methods have given decreased differences in yield determinations. If the need arises, this work could be resumed at any time.

The grades for lamb and mutton carcasses revised in 1959 to permit reduced requirements, particularly for the Prime and Choice grades, have been used more extensively by the industry than were the former grades, as is indicated by more total volume being graded. The new standards seem to be generally acceptable to the industry. A cooperative study was initiated by several interested groups, including the USDA, with the primary purpose of finding more efficient methods of merchandising lamb through use of different cutting procedures, more attractive packaging, and better advertisement. Final results of this study have not as yet been determined.

4. Future Plans and Needs

Wool warehouse testing and demonstrational work will be continued during Fiscal Year 1963. Comparisons will be made of clean yields obtained from core testing in this field work and those from commercial testing companies when the lots are sold on a core basis. With an apparent change in wool marketing involving an increased number of small local pools, it may be advisable to plan additional work with pool operators to explain and demonstrate grading, inspection, and classification procedures and their application in marketing. Testing of the Coulter Counter shall be continued, as it appears quite promising as an aid in the rapid determination of fineness and variability, in cooperation with the Market Quality Research Division and the Agricultural Research Service.

Studies shall be continued to attempt to find ways to improve the present lamb and mutton standards. In a report by McKinsey & Company, management consultants, to the American Sheep Producers Council in June 1962, it was stated: "A serious obstacle to product improvement is the current lack of an effective means for conveying to the producer those animal specifications that reflect consumer preferences and retailed product offerings...An appropriate grading system is of vital importance in correcting this situation...We favor a Government grading system because of its ready availability and established acceptance by retailers and consumers alike." Along this line, measurement and cutting data for lamb and mutton carcasses collected in previous years have been subjected to extensive statistical analysis and study to determine the factors responsible for differences in yields of cuts. It is planned to incorporate, in some revised standards, some system of identifying differences in yields of cuts of lamb and mutton carcasses in addition to identification of quality differences, as is now done in the standards.

5. Publications

Which Lamb Carcass Yields Highest Percentage of Retail Cuts? Karl E. Hoke and Robert W. Norton. Agricultural Marketing. September 1961.

USDA Plans To Propose Revised Wool Standards and Present Grade Uniformity Guides. Elroy M. Pohle. A presentation to the American Society For Testing and Materials, Committee D-13, Subcommittee A-3, On Wool, New York, N. Y. October 16-19, 1962.

SHEEP AND WOOL STATISTICS PROGRAM
Agricultural Estimates Division, SRS

The purpose of the statistical and other reporting services for agricultural commodities of the Department of Agriculture is to provide accurate, timely, unbiased facts for use in appraising the situation and in making current and long-range plans. Historically the statistical reporting service was started over 100 years ago to meet the need expressed by farmers to know as much about crop, livestock and poultry supplies as the people to whom they sold. Today, this type of information is widely used by farmers, processors, distributors, lending agencies, local, State and Federal Governmental agencies and other agricultural interests. With the exception of the Bureau of the Census, in the Department of Commerce, which takes a census of agriculture every 5 years, no Governmental agency outside the Department of Agriculture provides any considerable body of official statistics pertaining to agriculture.

The reporting and statistical services include for a wide range of crop, livestock and poultry commodities, current national and State estimates of acreage, inventories, production, livestock slaughter, prices received and paid by producers, value of production and sales and related information. This service work is cooperative and depends to a large degree on the voluntary reporting of information by farmers and by the business men who deal with farmers. These public spirited individuals cooperate with the Department in pooling their information for the common good.

The organizational structure of the Statistical Reporting Service consists of the Agricultural Estimates Division, Field Operations Division, the Crop Reporting Board, and Standards and Research Division. Within AED are the following branches: Livestock and Poultry, Dairy, Field Crops, Fruit and Vegetable, and Agricultural Prices. FOD consists of 43 State statistical offices and the Survey Operations Group. The following branches are located in the SRD: Data Processing, Research and Development, Special Surveys and Statistical Clearance. For more information see "Major Statistical Series of the USDA Volumes 1 and 8, Agricultural Handbook No. 118."

## 1. Objectives of the Program for Sheep, Goats, Wool and Mohair

The aim of this reporting service is to make estimates by States and for the United States on inventory numbers, production, marketing, inshipments and prices of sheep and lambs, wool production and mohair production, and to issue timely reports on current and prospective supplies. This involves collecting, compiling, and analyzing data from many sources, such as individual producers, stockyards, packers, processors, handlers, cooperatives, warehouses, and pullers, as well as from railroads and State and Federal Regulatory agencies.

## 2. Procedure for Conducting the Program

Most of the basic information is collected, analyzed, and estimates are prepared by the State Statisticians. These estimates are reviewed by the Crop Reporting Board and the official estimates adopted. The Board issues releases showing the estimates by States and regions, and in turn the State Statistician issues reports which include supplemental information and details of local interest. In a substantial number of States, an agency, such as the State Department of Agriculture, or the College of Agriculture, cooperates with the U. S. Department in maintaining a joint statistical service for agriculture under the direction of the State Agricultural Statistician. In these States local area and county statistics and other special reports are prepared and published as a part of the State program supplementing the basic Federal program, which is concerned primarily with State and National estimates.

## 3. Activities, Accomplishments, and New Developments

The established series of reports under this program were continued during the year and some of the reporting programs were expanded. Considerable attention has been given to modifying procedures in order to better meet the growing needs for statistical reports, and to keep up with the changes that are under way. The demands by farmers, industry groups, government agencies and others for more frequent, more comprehensive, more detailed, and more precise reports have continued. Factors affecting the work are the dynamic changes that characterize the livestock and poultry industries, including increased specialization and commercialization and the declining importance of side line production.

The statistical reporting program includes the following types of data by States: January 1 inventory numbers of all sheep and stock sheep; sheep and lambs on feed; production, disposition, and income of sheep and lambs; sheep and lamb slaughter; lambs saved; wool and mohair production and value; feeder sheep inshipments; and range and range sheep condition. The regular reports are listed under "Publications."

The project for improving methods of data collection was continued in 1962. Starting in 1961, the program was put on an operational basis in eleven Southern States and four North Central States. Five additional North Central States were added to the operational program in 1962 and four additional States are expected to be added in 1963. Pilot studies were made in seven States in 1962. Further expansion of the operational program will be realized as additional funds become available. The results of the operational and pilot programs and related work are analyzed, and modifications introduced in the operating program as their value is demonstrated.

Congress appropriated funds for a report on numbers of sheep and lambs on feed as of November 1, January 1, and March 1 of each year, starting in November 1960. This expansion, as recommended by the Sheep and Wool Research and Marketing Advisory Committee, involves a November 1, January 1, and March 1 report of number on feed, marketings and placements in seven leading lamb-feeding States. This report has met with favorable reaction from the livestock trade.

## 4. Future Plans and Needs

The Congress appropriated funds to be used as part of the long-range program for strengthening and improving the overall Agricultural Estimates program. Improvement in sheep and wool statistics can be expected as part of this program, but except for feeder reports, funds were not made available for new specific surveys in this area.

Increasing demands continue to be placed on the sheep, wool, and mohair statistical program to keep up with the changes that are under way in the industry and to adequately meet present day demands.

## 5. Publications

The following reports which include data on sheep, wool and mohair are issued regularly by the Crop Reporting Board, USDA, Washington, D. C. Excerpts from most of the reports, with supplementary State and local material, are issued by the State Agricultural Statisticians' offices in each State:

| | Approximate release date |
|---|---|
| Sheep and Lambs on Feed January 1<br>Number on feed, by States | January 10 |
| Sheep and Lambs on Feed November 1, January 1, and March 1<br>Number on feed, marketings, placements, and weight groups for 7 States | 10th of month concerned |

| | |
|---|---|
| Livestock and Poultry Inventory, January 1<br>Number, value, and classes, by States | February 13 |
| Wool Production and Value of Sales<br>Number of sheep shorn, wool production and value, by States | February 27 |
| Mohair Production and Value of Sales<br>Number of goats clipped, mohair production, and value, by States | February 27 |
| Early Lamb Crop<br>Early lamb crop situation in 10 States | March 10 |
| Meat Animals - Farm Production, Disposition and Income<br>Data by States | April 28 |
| Total Livestock Slaughter, Meat and Lard Production<br>Commercial and farm slaughter and meat production U. S. | May 1 |
| Lamb Crop<br>Number of lambs saved, by States | July 28 |
| Shorn Wool Production<br>Number of sheep shorn and wool production, by States | July 31 |
| Commercial Livestock Slaughter and Meat Production<br>Number of head and live weight of cattle, calves, hogs, sheep and lambs slaughtered in commercial plants by States, meat production by species and lard production for the United States | Last working day of each month |
| Revisions by States and by months for the previous year | April 28 |
| Shipments of Stocker and Feeder Cattle and Sheep<br>Monthly data for stocker and feeder cattle and sheep received in selected North Central States, by States. Monthly data for cattle and calves, sheep and lambs by market origin and State of destination. | About the 24th monthly |
| Western Range and Livestock Report<br>Condition of ranges, cattle, and sheep, by States, Western States | About the 10th monthly |

Wheat Pasture Report — About the 12th monthly

Condition and availability of volunteer and seeded wheat acreage. South and Central Plains Area - September 1, October 1, November 1 and December 1

Prices Received by Farmers — Near the end of each month

Mid-month prices received by farmers for sheep, lambs and wool

(The season average price received by farmers for wool and mohair for the marketing year is published about June 20, and also included in the June issue of "Agricultural Prices." These marketing season estimates are used in computing the incentive payment percentage for wool and mohair.)

The following special report was issued during the past year:

Wool and Mohair, Production and Value, United States and by States 1909-59, Statistical Bulletin No. 309, USDA, Statistical Reporting Service, April 1962